Chemical Engineering

A McGRAW-HILL PUBLICATION

JUNE 20, 1960

Published every-other-Monday

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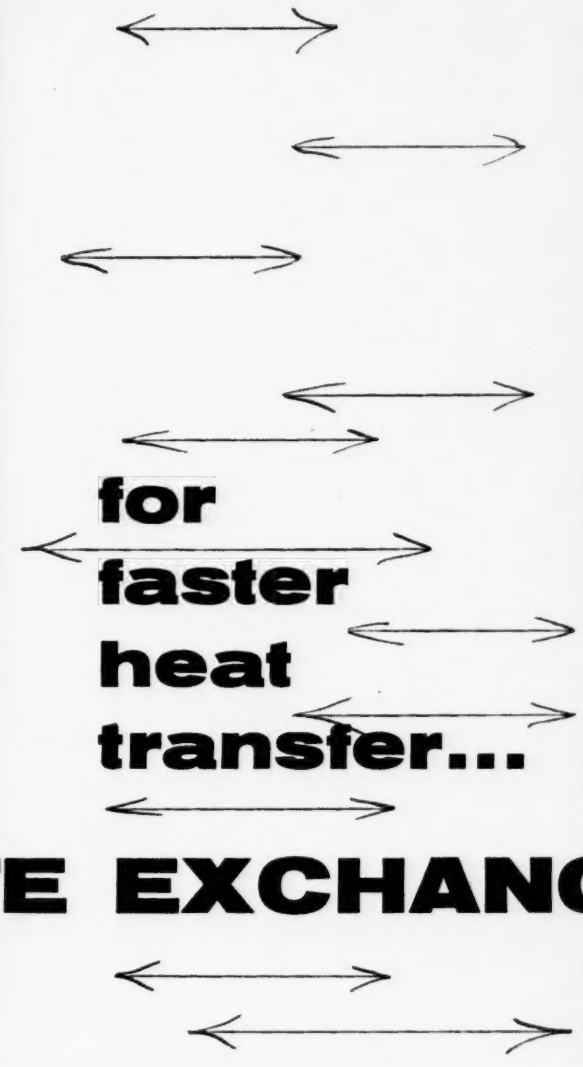

for faster heat transfer...

PLATE EXCHANGERS

Advantages of plate-type exchangers

What does tonnage oxygen cost?

Management looks at education woes

SEE PAGE THREE

Completes 46 Structures in 4 Months

at Petroleum Chemicals, Inc.

CB&I's *coordinated services* played a major role in construction of three new petrochemical plants recently placed on-stream by Petroleum Chemicals, Inc., at Lake Charles, Louisiana.

CB&I's assignment: Fabricate and erect 13 processing towers and 33 storage tanks for an expansion program that would—and did—put three plants in operation during a four-month period.

The new plants—ammonia, ethylene and ethylene oxide-glycol—have catapulted Petroleum Chemicals into a major petrochemicals producer, less than four years after its founding.

Companies on the move, such as Petroleum Chemicals, know they can depend on CB&I's *coordinated services* to meet exacting specifications and schedules. The reason: Expert, *one source* responsibility for engineering, fabrication and erection.

These are the benefits of CB&I's seven decades of *craftsmanship in steel*. Write our nearest office for the bulletin: *Development of the Oil Storage Tank*.

Propane is stored in these vertical blimps built by CB&I for Petroleum Chemicals. Each structure is 60 feet high, 12½ feet in diameter and has a 1,500-barrel storage capacity.

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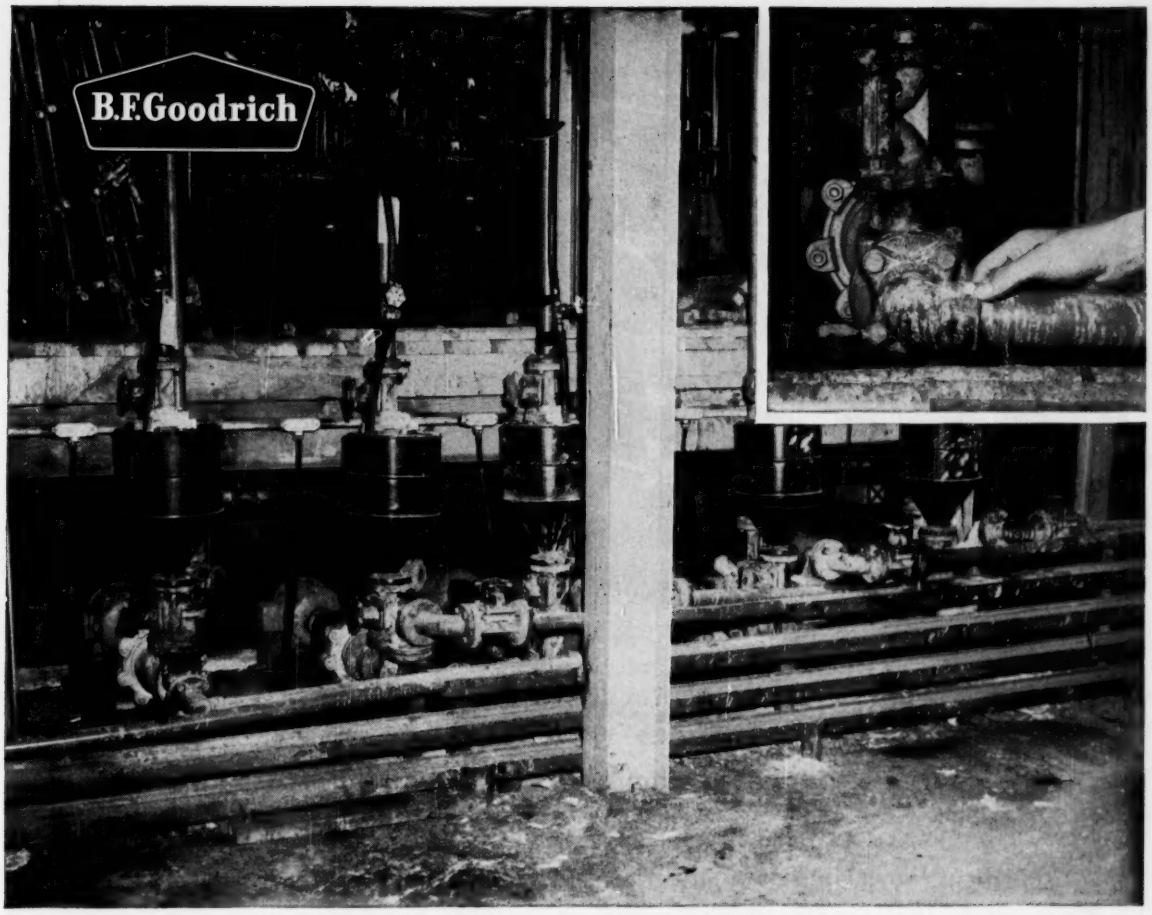

Koroseal knocks out corrosion in auto bumper plant

HOUDAILLE Industries makes and nickel-plates automobile bumpers in this Huntington, West Virginia plant. Regular pipe fails fast when exposed to the hot, highly corrosive nickel solution.

Here, on this filter system, B.F.Goodrich Koroseal polyvinyl chloride pipe and socket fittings solved the problem. Koroseal pipe and fittings are unaffected by most acids and alkalies, completely inert in the presence of oil, alcohol and salt solutions.

Countless manufacturers have solved difficult problems with versatile Koroseal pipe. It's inexpensive, light and easy to install. It can be threaded, cut, welded or drilled. Koroseal pipe has superior insulation qualities, will not support combustion and never needs to be painted.

Koroseal rigid PVC has high impact resistance and is available in tubes, rods, valves and sheets. For information on how B.F.Goodrich Koroseal can make your operation more efficient, more profitable, simply send in the coupon below.

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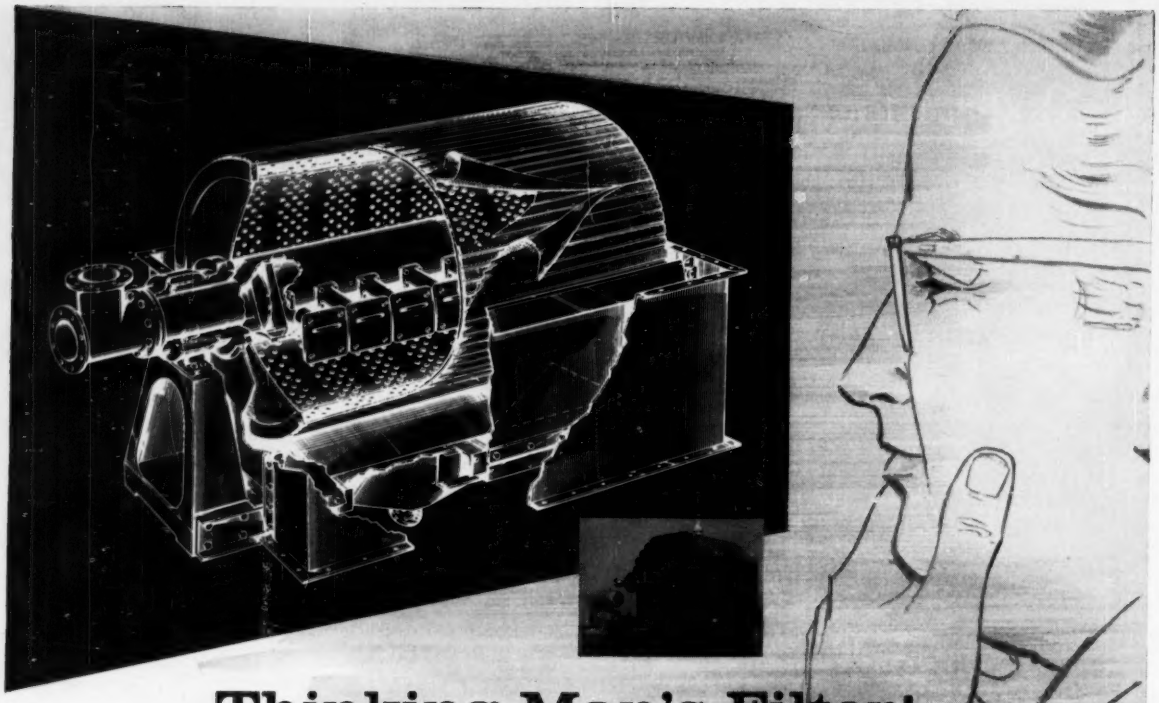

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Here is a pigmy-size vacuum filter with a giant's capacity

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3. Thin cakes can be effectively discharged, making it possible to use high drum speeds.
4. Maximum capacity can be sustained indefinitely, due to complete cake discharge via pneumatic blowback.

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June 29, 1959 **Chemical Engineering** Vol. 66, No. 13

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Chemical Engineering (with Chemical & Metallurgical Engineering) is published biweekly by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder. Publication Office: 99-129 North Broadway, Albany 1, N. Y.

Executive, Editorial, Circulation and Advertising Offices, 330 West 42nd St., New York 36, N. Y. Officers of the McGraw-Hill Publishing Co., Inc.: Donald C. McGraw, President; Joseph A. Gerardi, Executive Vice President; L. Keith Goodrich, Vice President and Treasurer; John J. Cooke, Secretary. Officers of the Publications Division: Nelson L. Bond, President; Harry L. Waddell, Senior Vice President; Ralph B. Smith, Vice President and Editorial Director; Joseph H. Allen, Vice President and Director of Advertising Sales; A. R. Venesian, Vice President and Circulation Coordinator.

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Subscriptions: Send correspondence and change of address to Fulfillment Manager, Chemical Engineering, 330 West 42nd Street, New York 36, N Y. Send notice promptly for change of address, giving old as well as new address. Enclose an address label from a recent issue of the magazine if possible. Allow one month for change to become effective.

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National Carbon representatives expand your engineering force

T. W. MANCHESTER – SALES ENGINEER

Mr. Manchester was graduated from Pennsylvania State University with a B. S. Degree in Chemical Engineering. For nine years he worked as a Product and Process Control Engineer at National Carbon's Clarksburg and Columbia Plants. Here he was involved with production control for the manufacture of electrodes, anodes and specialty grades of graphite.

After joining the Chemical Products Sales Group, Manchester worked for a period in the design group. Since 1958, he has been a field engineer covering the Southeastern Sales District.

LARGE DIAMETER GRAPHITE STOCK FILLS NEED OF CHEMICAL PROCESS INDUSTRY

Unloading 61" diameter x 72" long graphite from graphitizing furnace

National Carbon Company has completed production of the largest diameter fine-grained graphite specialty stock ever produced. These pieces are 61" in diameter, 72" long and weigh approximately 7 tons each.

The production of this large size graphite allows fabrication of essentially monolithic high temperature process equipment. Monolithic construction lends itself to easier field erection and lower maintenance because it minimizes the number of joints required.

Five of these pieces are to be machined into sections for a graphite tower. The tower will be used for production of phosphoric acid from the burning of elemental phosphorous.

This is another example of National Carbon's continuing research, development and production efforts to meet the growing demands of the chemical processing, nuclear, and aircraft industries for large size graphite stock.

Carbon and Graphite unmatched as materials for high-temperature applications

In recent technical articles covering materials of construction for high-temperature chemical processes, reference is made to graphite as the best available material for applications in neutral or reducing atmospheres. At temperatures up to 4000° F., graphite exhibits excellent structural properties such as: no deformation, relatively high strength, immunity to thermal shock and, most important of all, is its complete chemical inertness.

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NATIONAL CARBON Engineers have gained extensive experience in the development of equipment for these high-temperature chemical applications. This experience can prove helpful in the design of equipment for new applications. If you wish to consult a NATIONAL CARBON Engineer, write **National Carbon Company, P. O. Box 6087, Cleveland 1, Ohio.**

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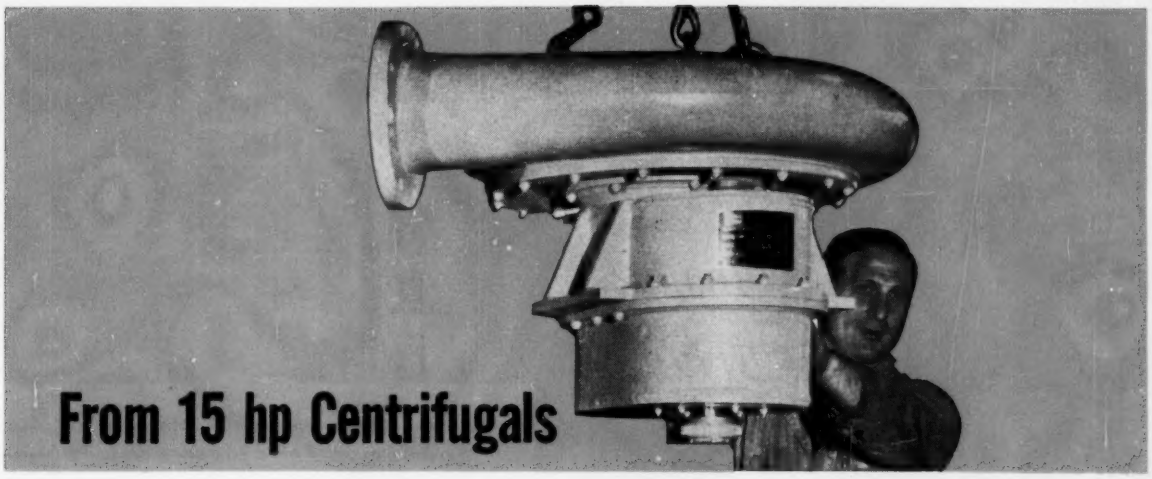

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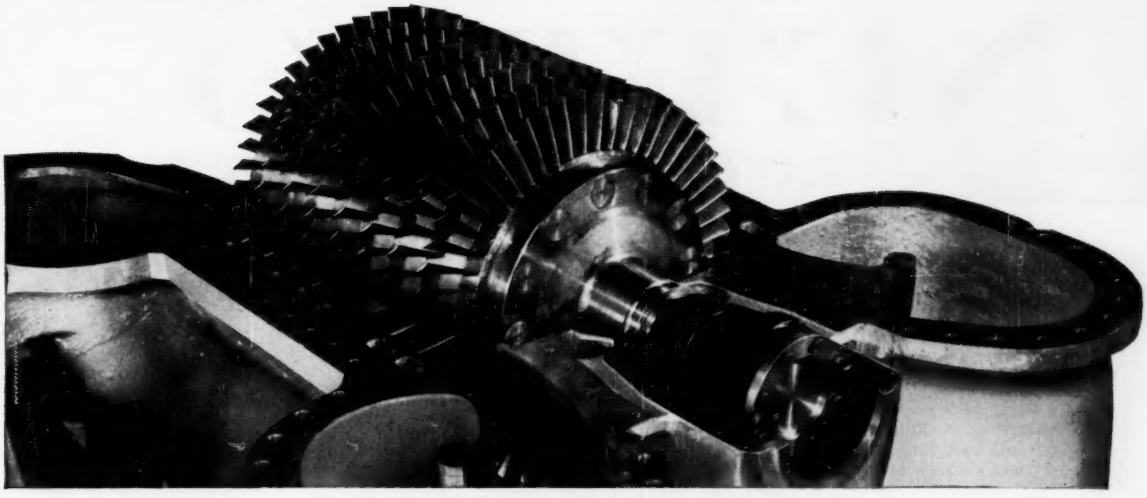
to 15,000 hp Axials . . .



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Compactness and efficiency are achieved in all Joy dynamic compressors through high stage performance. Advanced aerodynamic concepts and modern metallurgy have contributed to designs which provide the maximum of compressed air or gas for power consumed and floor space occupied.

Joy Axial-flow and Centrifugal Compressors will prove the most economical solution, whether you are compressing plant air, or process air or gas, at normal or elevated pressures and temperatures. If you have an air or gas compressing problem, check with your Joy representative or write for our bulletin "Joy Turbodynamics."

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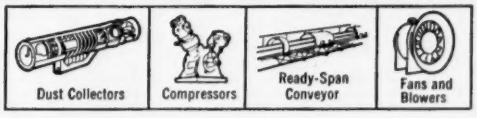

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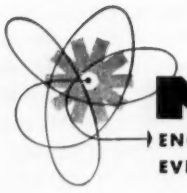

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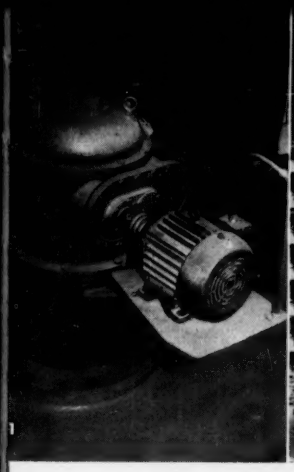

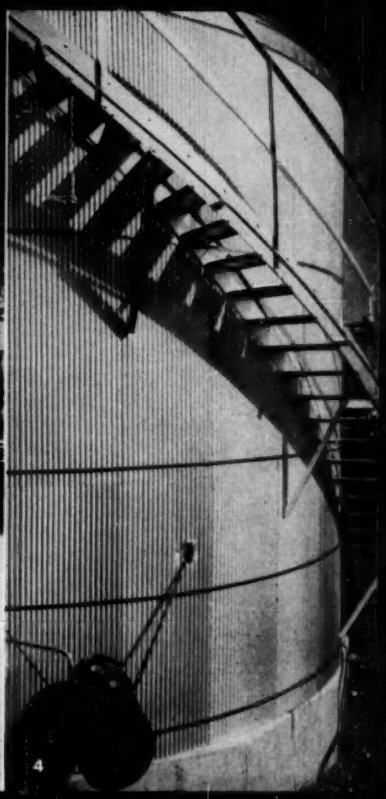

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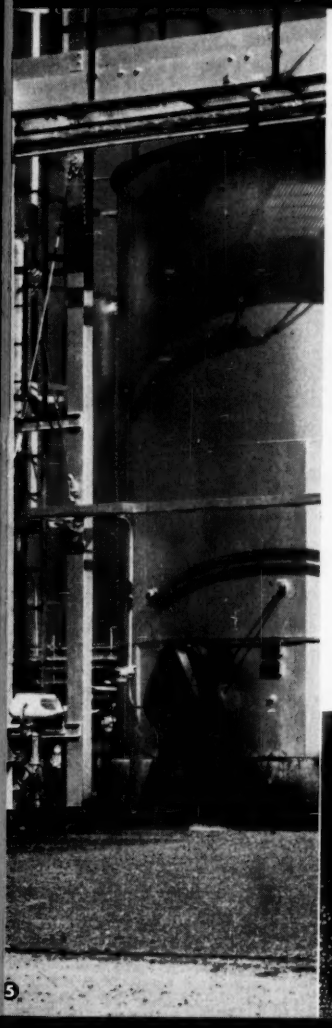

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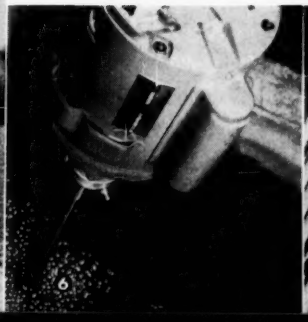

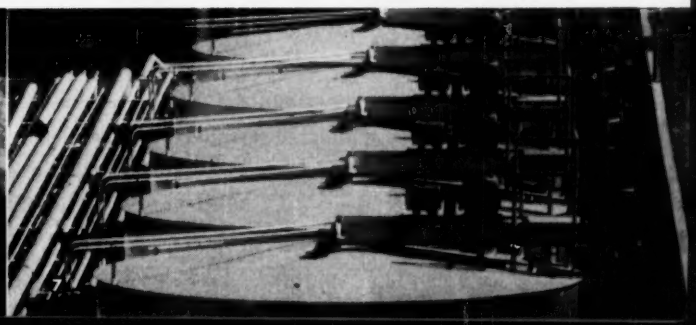

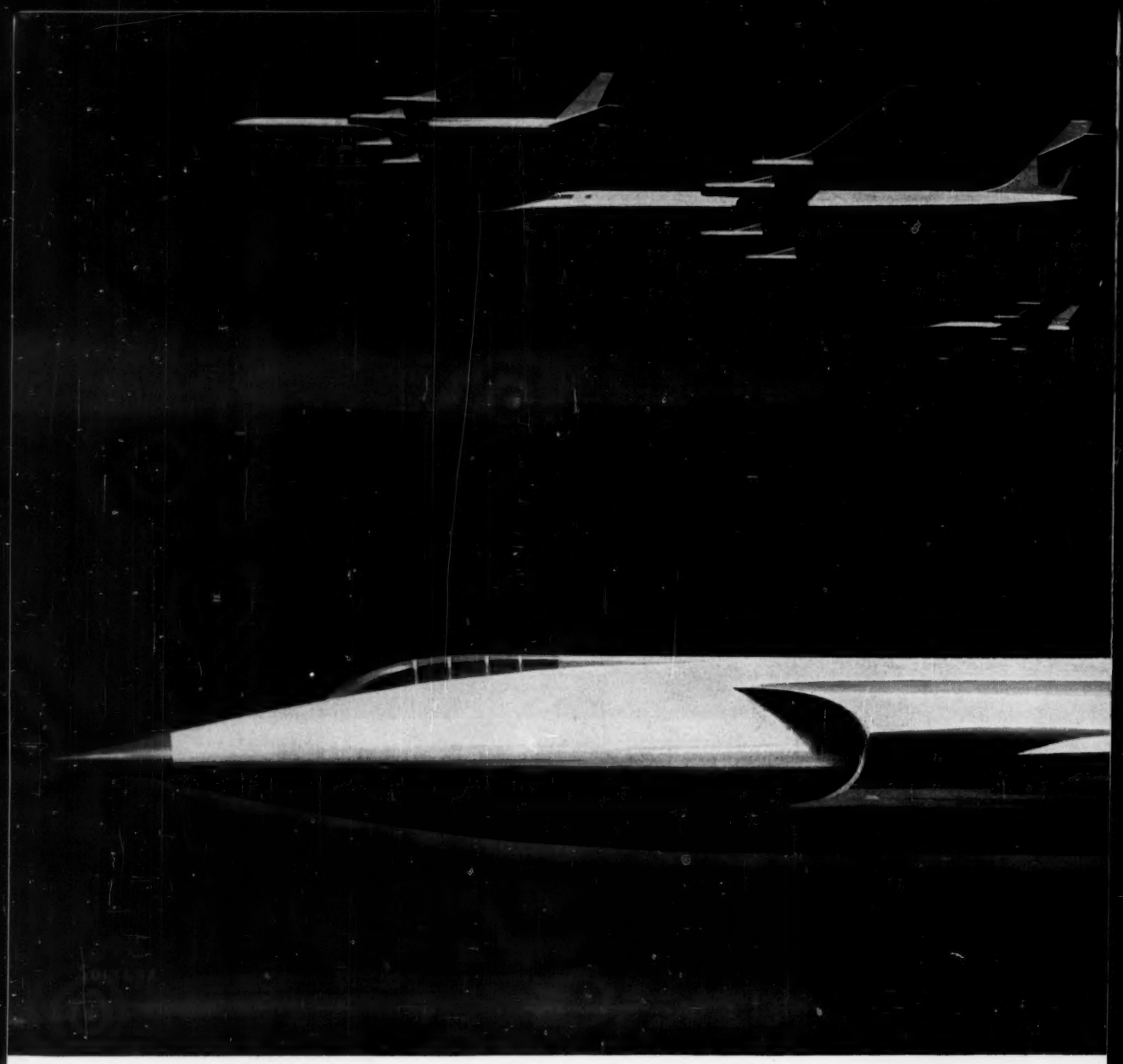

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New Celanese synthetic lubricants have hurdled the heat barrier set up by high bulk oil temperatures in jet engines. These lubricants withstand 425°F . . . more than 100° higher than any previously available. Highly significant, too, is the fact that they efficiently meet viscosity requirements at temperatures down to −65°F. Their potential has barely been tapped. For instance, they may become of utmost importance in such broad fields as heat transfer, automotive, and steel and aluminum forming. Continuing research and progress by Celanese in high-temperature lubricants has broadened and sharpened our national defense capabilities and has enabled great improvement in industrial machinery design. If you have a high-temperature lube problem, why not ask us to help? Simply write to Celanese Corporation of America, Chemical Division, Dept. 653-F, 180 Madison Avenue, New York 16, New York.

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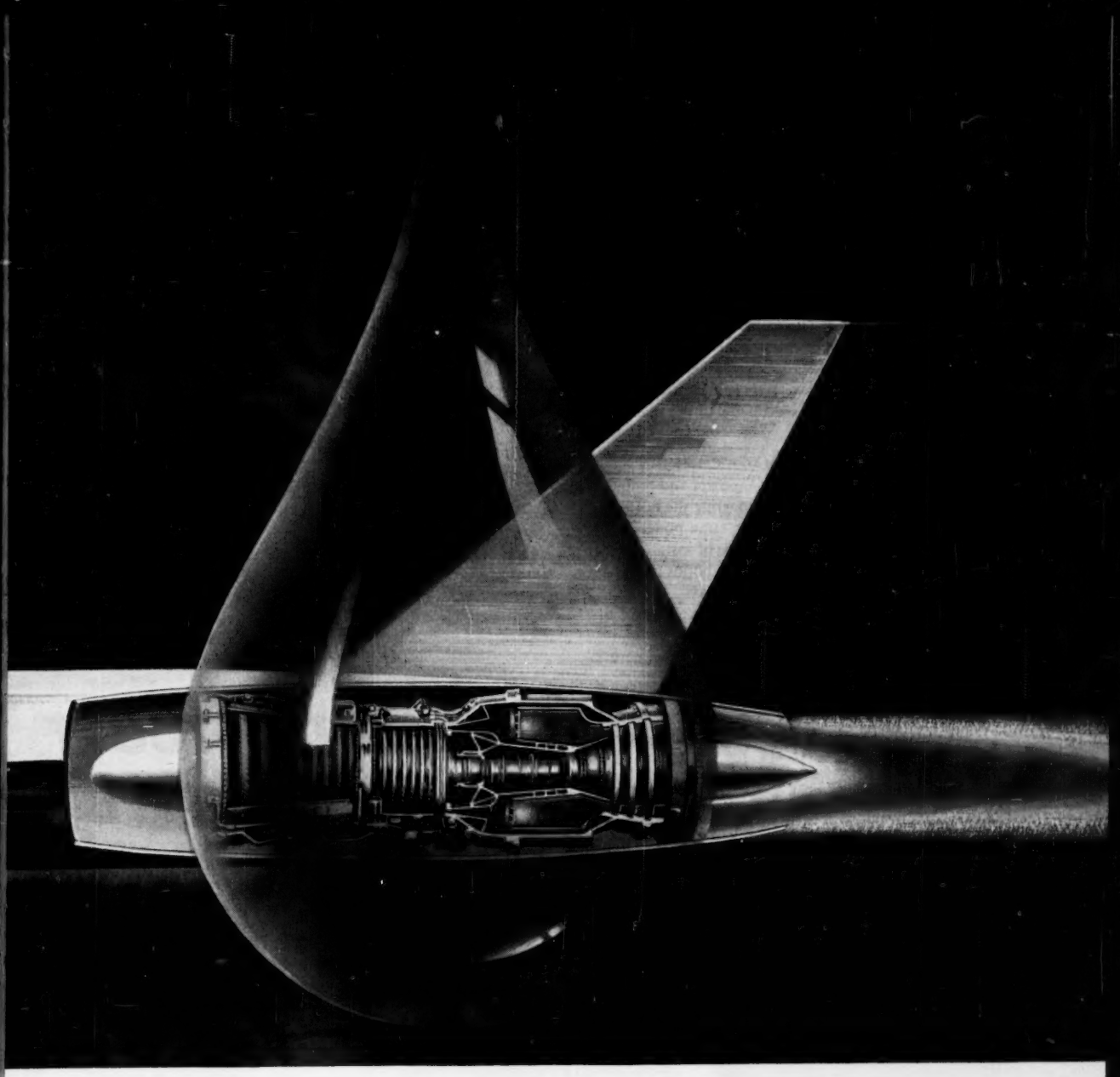
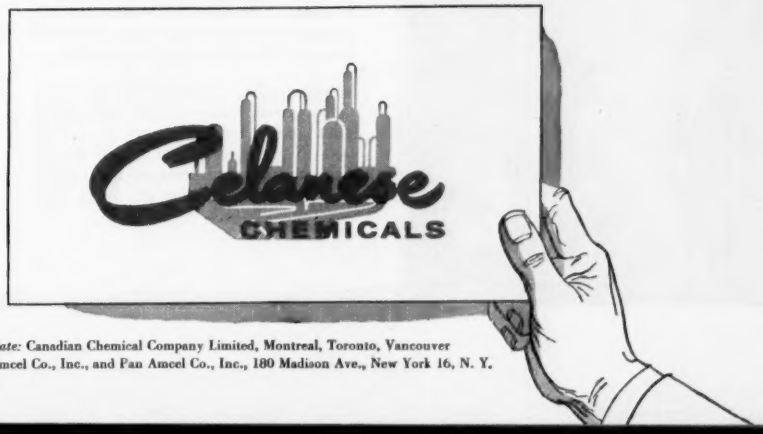


opens the way for new superspeed jets



Canadian Affiliate: Canadian Chemical Company Limited, Montreal, Toronto, Vancouver
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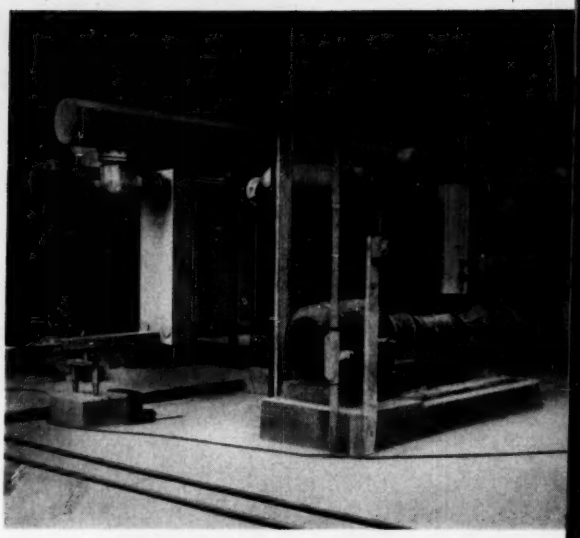
Fred Wheelwright, Manager, Industrial Sales:

"Two kinds of difficulties arise in the selection of process equipment. The *first* consideration, process efficiency, gives us no difficulty at De Laval. Well-documented performance specifications are reinforced with thorough pilot plant trials at De Laval laboratories when necessary. Each piece of De Laval process equipment is *known* to be capable of doing its job at time of sale.

"The *second* is the joint consideration of tight space availability, scarce manpower and budget. Our success, too, in meeting the needs of space and manpower economy – and budget – is borne out by many thousands of installations. It reflects a performance bonus from the design ingenuity of equipment just *naturally* built to perform with a maximum economy of space and manpower. Three examples are shown here."



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Viscous liquid easily separated in pressurized centrifuge

Problem: A viscous, high-melting-point rubber accelerator was to be separated from an alcoholic reaction mixture.

Solution: Centrifugal separation at liquefying temperatures. This also meant maintaining pressure to avoid alcohol boil-off. An open-system separation was not practical but tests at De Laval's pilot plant proved the Hermetic Centrifuge could handle this job. In actual production, instantaneous and complete separation was easily achieved with a De Laval Hermetic Centrifuge to provide a clean product and no loss of the alcohol phase.

Similar separation problems involving elevated temperatures and pressures can be handled by the many standard types of De Laval Hermetics. Corrosion-resistant and easy to clean, these centrifuges meet all the requirements of industrial service. As in the case quoted here, our technical service in providing the *right* design for volume and purity requirements often includes pilot plant pre-testing before shipment. Please write for details.

Batch-process blow steam provides steady-source heat

Problem: For a 15 or 20 minute period, the discharge of a pulp-digester autoclave produced "waste" steam totaling 255,000 pounds per hour. How to reclaim this heat without resorting to a large shell and tube heat exchanger?

Solution: The periodic blow steam was condensed by a small jet condenser discharging into a hot water storage tank. Cycling this hot water through a compact De Laval Plate Heat Exchanger provided a continual heat source to raise the temperature of 409,000 pounds per hour of incoming process water from 110°F. to 160°F. Cooled storage tank water at 130°F. is reused in the jet condenser, maintaining a closed system.

This Bowaters Carolina Corporation installation at Catawba, S. Carolina, not only converts this intermittent waste heat into a continuous source of hot process water but does it in a small compact unit based on the unusually high efficiency of the De Laval Plate Heat Exchanger. The stainless steel plate construction assures a long life and quick access for easy cleaning when required.

For more conventional heat-transfer problems, the De Laval Plate Heat Exchangers offer the same unique combination of structural compactness, transfer efficiency and easy operation. We would be pleased to help you evaluate their benefits in any of your existing or contemplated heat exchange processes. No obligation, of course.

PRODUCTION REQUIREMENTS DE LAVAL PROCESS EQUIPMENT

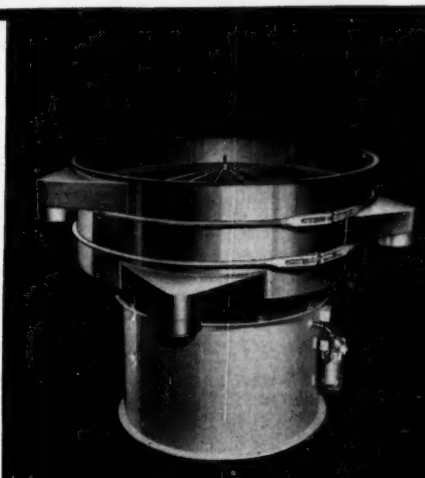
CENTRIFUGES • PLATE HEAT EXCHANGERS • VIBRATING SCREENS • COMPLETE PROCESSES

3-way vibration ups output 91% and prevents loss of usable coarse fines

Problem: As received from dryer, muriate of potash contained considerable fines and required dedusting before bagging and warehousing. The existing gyratory screeh separator could not handle the load.

Solution: The *three dimensional motion* of a De Laval Syncro-Matic Separator increased screening efficiency to give 91% greater product throughput. The more thorough screening action also permitted the use of a 24-mesh bolting cloth in place of the coarser 18-mesh bolting cloth previously found necessary. An extra benefit of the increased throughput, therefore, was the recovery of fine crystals that in the original equipment were lost with the fines.

Constructed of carbon steel or stainless steel, the De Laval Syncro-Matics accommodate a full range of screen sizes and are available in one, two or three decks. Screen motion is *horizontal, gyratory* and *vertical* to provide unmatched screening efficiency. For more information, just write us on your letterhead. No obligation, of course.



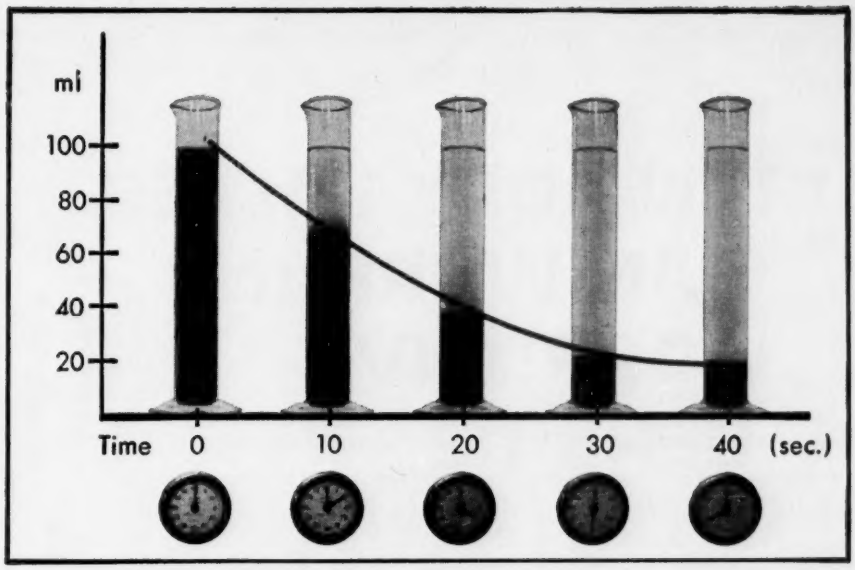
CYANAMID

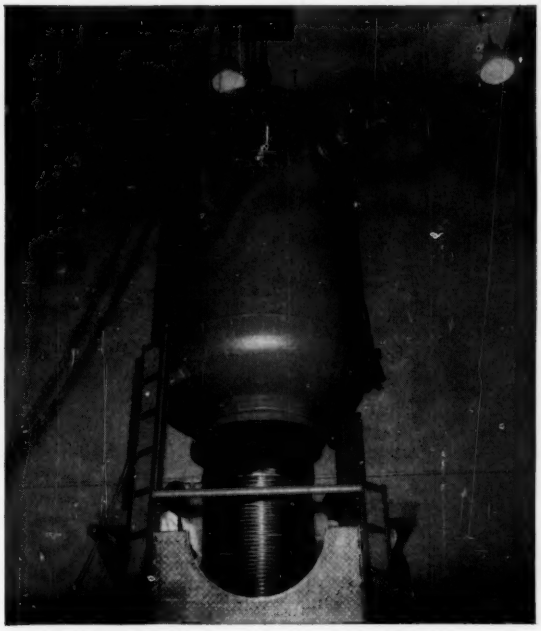
Chemical Newsfront

NEW LIFE FOR PLASTICS is the achievement of Cyanamid's CYASORB* UV 24 *Light Absorber*. This light-stabilizing chemical substantially improves the color retention and durability of vinyls, polyesters and other resins. Chemically, CYASORB UV 24 is 2,2'-dihydroxy-4-methoxybenzophenone, a pale yellow powder, which is relatively inert. It has absorptive characteristics through a wide range of the ultraviolet portion of the spectrum, and is particularly effective from 300 millimicrons, the lower end of the spectrum, to 380 millimicrons. Because of its high absorption capacity, it is low in cost on a performance basis. CYASORB UV 24 is especially beneficial in plastic films and surface coatings. **(Intermediates Dept.)**

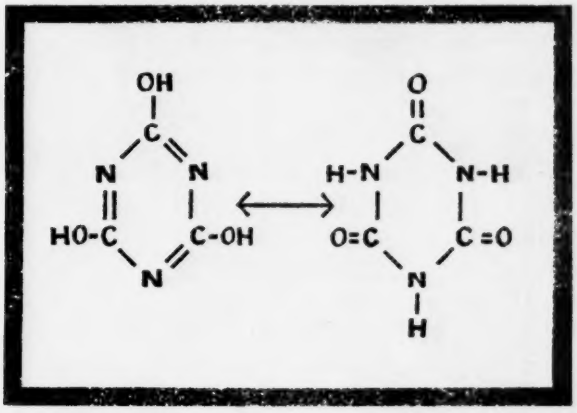
TWO NEW CYANAMER® WATER-SOLUBLE ACRYLAMIDE POLYMERS, P 250 and P 26, dissolve fast, give clear solutions. In the unretouched photograph, right, CYANAMER P 250 (right) has dissolved completely one minute after being added to water, while a competitive resin remains on the surface. P 250 is a high molecular weight polymer. It is an economical thickener for water solutions. P 26 is a low molecular weight product. It is ideal for blending with P 250. Mixtures of the two can be used to prepare solutions of desired solids-viscosity relationship. Write for more information. **(Market Development Department)**

INCREASED SETTLING RATES and clarity of overflow in thickening operations are achieved with SUPERFLOC® 16 *Flocculant*, Cyanamid's newest mining chemical, as demonstrated in the chart at right. Already used as a flocculating agent in uranium leaching operations, SUPERFLOC 16 is also applicable as a filtration and settling aid in other ore beneficiation processes, waste-treatment operations and in coal preparation. SUPERFLOC 16 is an effective settling and filtration agent in highly acid, neutral and alkaline suspensions. For complete information on the use and testing of various Cyanamid synthetic flocculating agents, write for our brochure. **(Explosives and Mining Chemicals Department)**





NEW BASIC RESEARCH TOOL, a 3-million volt Van de Graaff accelerator, has been installed at Cyanamid's Stamford Laboratories. Housed in the recently completed ionizing and radiation center, it will open up an entirely new area of radiation chemistry. Purchased after several years of exploratory research in the field of ionizing radiation, the accelerator will be used to study the effects of radiation on chemical and biochemical processes. **(Central Research Division)**



NOW CYANURIC ACID is offered for the first time in semi-commercial quantities by Cyanamid, a pioneer in triazine chemistry. Already developed as an intermediate for chlorinated dry bleaches and sanitizers, cyanuric acid is now available to the chemical industry for research and development in other areas. This low-cost, reactive triazine should find a spot in your future research and development program. **(Process Chemicals Department)**

*Trademark

CYANAMID

AMERICAN CYANAMID COMPANY
30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

AMERICAN CYANAMID COMPANY
30 Rockefeller Plaza, New York 20, New York

Gentlemen: Please send me further information on

- ☐ CYANAMER Water-soluble Resins
- ☐ SUPERFLOC 16 Flocculating Agent
- ☐ CYASORB UV 24 Light Absorber
- ☐ Cyanuric Acid

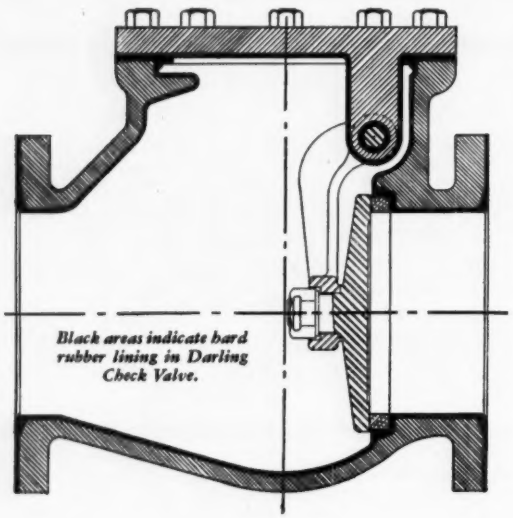
Name_____ Title_____

Company_____

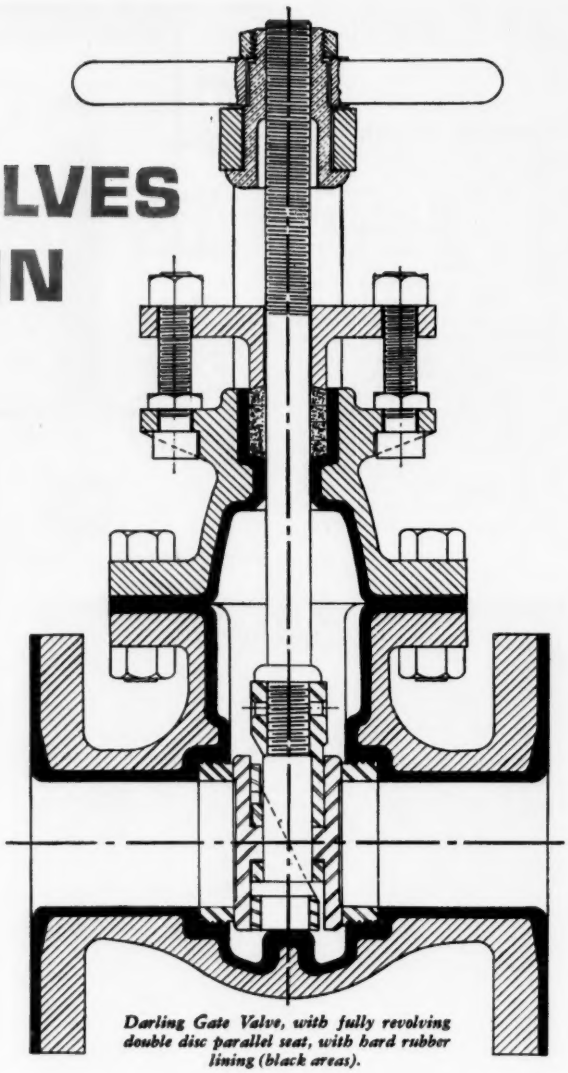
Address_____

City_____ Zone_____ State_____

IRON BODY VALVES CAN WORK IN CORROSIVE SERVICE



Black areas indicate hard rubber lining in Darling Check Valve.



Darling Gate Valve, with fully revolving double disc parallel seat, with hard rubber lining (black areas).

Rubber-Lined Check Valves...Gate Valves

Here's a way to make substantial savings in valves for corrosive or abrasive service. Darling Iron Body Check Valves and Gate Valves may be obtained with special hard rubber linings. This means you can often save the cost of expensive special alloy valves, yet obtain high resistance to corrosion or abrasion.

Darling Check Valves employ a streamlined body design especially selected for application of hard rubber lining. Excess area through the valve minimizes abrasion and insures full delivery of line capacity.

Darling Rubber-Lined Gate Valves give you the advantages of the revolving double disc parallel seat and "no pocket" discs... which provide positive sealing and assure ease of operation. Available in outside screw and yoke type, in sizes from 2" to 24". Write for further information.

DARLING VALVE & MANUFACTURING CO.

Williamsport 3, Pa.

Manufactured in Canada by Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ont.

DARLING VALVES

Perhaps you, too, can profit from

Air Products
...INCORPORATED

CAPACITY

... capacity to design, produce, install and operate *complete systems* for separation, purification and liquefaction of gases – systems that provide profitable advantages and opportunities throughout industry.

Liquefied gases from Air Products equipment supply all major U.S. missiles.

HOW THE MILITARY SERVICES use Air Products CAPACITY

Large-scale low-temperature systems, ultra pure gases and liquids, and a broad range of specialized cryogenic "hardware" are supplied by Air Products to the military. When large quantities of liquefied gases were needed for rocket engine development and missile testing, Air Products quickly designed, manufactured and put on stream complete production facilities. Typical facilities paid for themselves in less than a year's time. Air Products also provides a broad line of portable air separators for field and shipboard use . . . and has advanced the development of exotic fuels. And, Air Products produces advanced design liquefied-gas pumps, cryogenic storage and transfer systems, electronic cooling devices and refrigeration and distillation equipment for military uses.

YOU will find here tangible evidence of a growing technology. Applying "Cryogenics" (the science of low temperatures) and engineering broad new routes to low-cost, high-purity industrial gases is the main business of Air Products.

Air Products combines original research knowledge with engineering and manufacturing capabilities and substantial operating experience. These integrated activities have

These companies and many others are the beneficiaries of major facilities provided by Air Products:
• Acme Steel • Bethlehem Steel • Brazilian National Steel • Celanese • Dow Chemical • du Pont • Grace Chemical • Great Lakes Steel

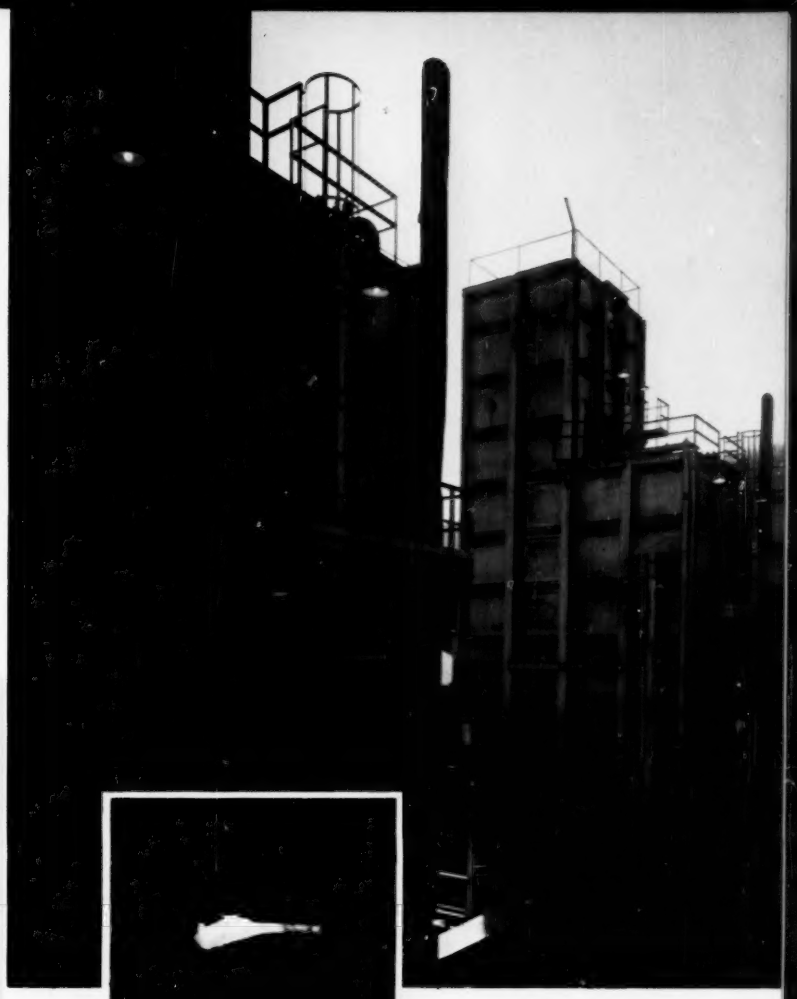
Petrochemical plants use Air Products equipment in feedstock preparation and product purifications.

HOW THE STEEL INDUSTRY uses Air Products CAPACITY

In the blast furnace, the open hearth and the new converter processes — Air Products oxygen efficiently increases steel mill capacity. Annealing nitrogen and other gases are also provided on a low-cost tonnage basis.

Air Products' complete gas supply systems are installed at steel mills without capital investment or operating worries on the part of the users. Continuity and reliability of supply are assured. On-site facilities pioneered by Air Products reduced the cost of oxygen 80% in 12 years — transforming oxygen from a costly chemical to a practical working utility.

Further progress marks on-the-job development work now continuing around the clock at major steelmaking facilities. Entirely new metallurgical techniques . . . and new profits . . . are available through Air Products.



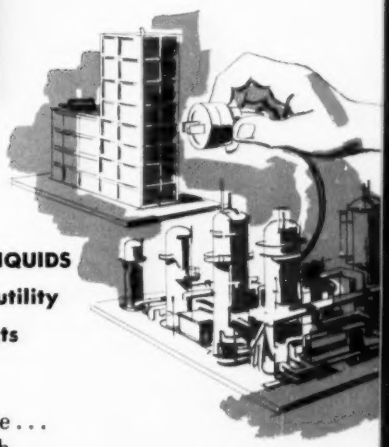
helped provide many Air Products customers with distinct competitive advantages.

Air Products is the world's leader in APPLIED CRYOGENICS — the practical and profitable use of low-temperature science for industry.

Perhaps this CAPACITY can help solve your problems — in cryogenics, in industrial gas supply systems, or in some new area where "ground rules" are yet to be established.

• Jones & Laughlin Steel • Osaka Oxygen • Spencer Chemical • Sun Oil • U.S. Government - All major research and defense projects • United States Steel • Venezuelan Ministry of Mines • Weirton Steel

Air Products pipeline oxygen serves the Basic Oxygen Furnace Process.



HOW THE CHEMICAL INDUSTRY uses Air Products CAPACITY

Air Products low-temperature systems permit many modern chemical plants to improve operating efficiency and end-product quality — and to develop new processes and products. This results from the ready availability of low-cost tonnage quantities of oxygen, nitrogen, hydrogen, ammonia and methanol syn-gas, carbon monoxide and hydrocarbons such as purified methane, acetylene and ethylene. Low-temperature separations of gaseous mixtures now make it practical to recover valuable components from natural gas, refinery off-gases, coke-oven gas and other "waste" gases. The versatility of cryogenics—as applied by Air Products—works profitably for the chemical industry today . . . offers unparalleled future opportunity in this fast-growing industry.

HIGH PURITY GASES AND LIQUIDS —available like any other utility with the help of Air Products CAPACITY

. . . The supply is dependable . . . the price guaranteed . . . with Air Products on the job.

Air Products INCORPORATED

Perhaps you, too, can profit from

Air Products

CAPACITY*

* To find the new opportunities Applied Cryogenics may offer in the manufacture, separation and purification of Industrial Gases.

* To provide integrated research, engineering, manufacture and operation . . . complete services under a single responsibility.

* To forecast accurately and guarantee total cost, superior performance and reliability.

* To put entire gas supply complexes to work for you *without capital investment on your part.*

Air Products CAPACITY has helped our customers to step out ahead of competition in familiar fields . . . to open up entirely new areas of opportunity through new products or processes. A letter or telephone call will put Air Products CAPACITY to work for you.

Information is available on:

superconductivity
frozen free radicals
biological preservation
environmental control
low-temperature
catalytic reactions
infrared detection
masers

purification and liquefaction of:

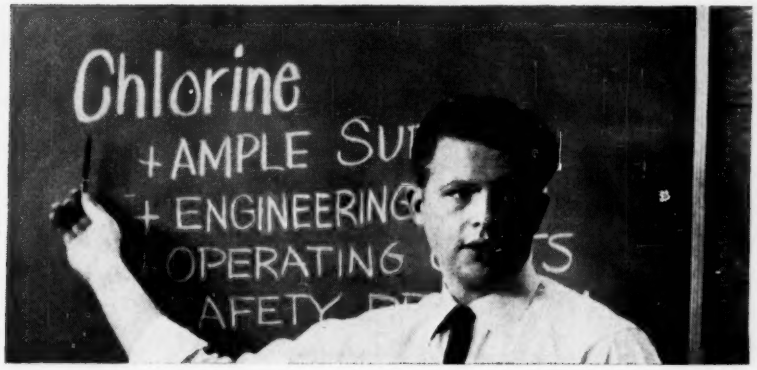
argon
carbon monoxide
ethylene
fluorine
helium
hydrogen
krypton
methane
neon
nitrogen
nitrogen trifluoride
oxygen
oxygen difluoride
ozone
xenon

Air Products ...INCORPORATED
ALLENTOWN, PENNSYLVANIA

Air Products (Great Britain) Ltd., London
Air Products, S. A., Caracas
Dynamic Research, Inc., Los Angeles

BRIEFS

on 4 chlorine "pluses" . . . a caustic soda guide . . . 3 built-in sodium sulfide controls . . . an important sulfide drum



You get these 4 pluses when you ask for *Hooker* chlorine

1. Engineering help. You can get aid from Hooker engineers in planning or revamping your chlorine handling system.

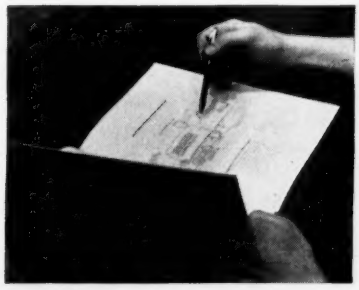
2. Operating hints. Our technical service men can often spot—and help you fix—troubles before they become serious. You get periodic technical service visits.

3. Safety programs. We keep you up to date on the safest and most economical handling methods.

4. Ample supply from Hooker plants which bridge the continent: Niagara Falls, Montague, Mich., Tacoma, and North Vancouver. And, of course, you get a chlorine that meets high industry standards when you ask for Hooker.

Send the coupon for our Chlorine Manual, 76 pages of useful facts on chlorine, its handling and usage.

Phone or write the nearest Hooker sales office for further information on how we can help you.



Fact-filled guide book gives data on handling caustic soda safely

Here is a practical, easy-to-use book on the safest ways to store and handle liquid caustic soda.

It tells you how to unload a tank car, gives methods for diluting caustic soda to different strengths, tells how to store efficiently and with least risk of iron pickup.

Large, detailed diagrams show you the equipment to use. 18 charts, graphs and tables help you foretell how caustic soda will act under a wide range of working conditions.

Get your free copy by checking the coupon.

Why our sodium sulfides are always full strength

Take a look at this drum.

It was planned to bring Hooker sodium sulfide and sulfhydrate to you at full strength and to keep it that way until it's used up in process.

This drum is lacquer-lined. It is sealed with lacquer around the cap. Six sturdy lugs hold the cap fast during handling and storing.

There's another reason you always get Hooker sodium sulfides at full strength—we use only new containers.

Check the coupon for specifications.

For more information on chemicals mentioned on this page, check here:

- ☐ Hooker Chlorine Manual
- ☐ Hooker Caustic Soda Guide
- ☐ Sodium Sulfide Data Sheet
- ☐ Sodium Sulfhydrate Data Sheet

Clip and mail with your name, title, and company address.

HOOKER CHEMICAL CORPORATION
406-2 Forty-seventh Street, Niagara Falls, N. Y.

Sales Offices: Chicago Detroit Los Angeles New York Niagara Falls Philadelphia Tacoma Worcester, Mass.
In Canada: Hooker Chemicals Limited, North Vancouver, B. C.

HOOKER CHEMICALS PLASTICS

Charles G. Cooper, *Vice President,*
The Cooper-Bessemer Corporation, explains...

How Cooper-Bessemer can serve you anywhere in the world

If you need heavy-duty engines or compressors, Cooper-Bessemer can serve you promptly with the world's most advanced designs . . . whether you are located in Europe, Asia, South America or any other area of the globe. We have developed an outstanding organization of representatives, subsidiaries and licensees to provide experienced, full-scope service throughout the world. These companies can supply your needs in Cooper-Bessemer products backed by experienced, highly efficient engineering and technical service.

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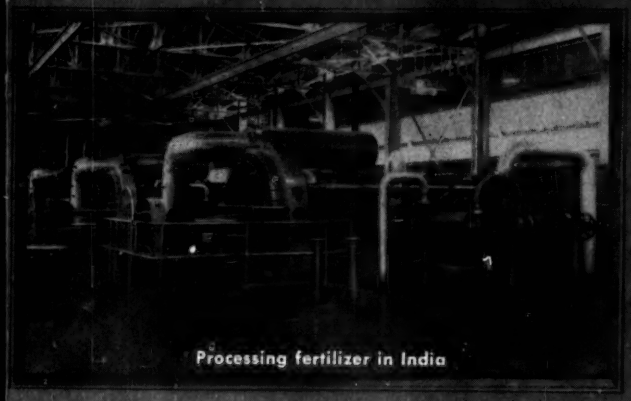
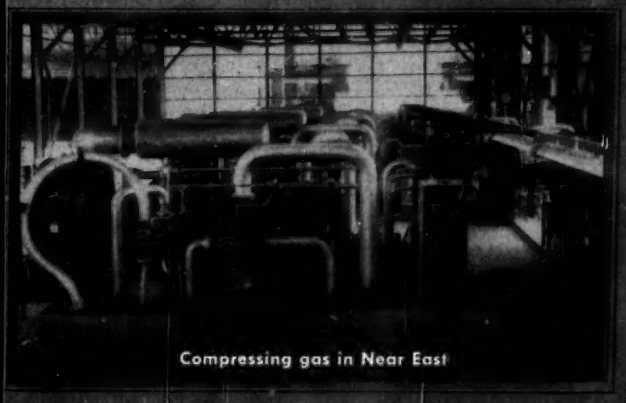
GENERAL OFFICES: MOUNT VERNON, OHIO

ENGINES: GAS • DIESEL • GAS-DIESEL
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL
ENGINE OR MOTOR DRIVEN

BRANCH OFFICES: Grove City • New York • Washington • Gloucester • Chicago • Minneapolis • St. Louis • Kansas City • Tulsa • New Orleans • Shreveport • Houston • Greggton • Dallas • Odessa • Pampa • Casper • Seattle • San Francisco • Los Angeles • *SUBSIDIARY:* C-B Southern, Inc., Houston



Processing fertilizer in India

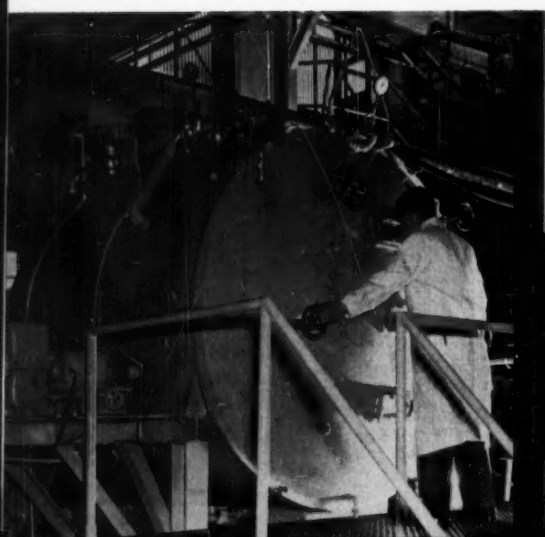


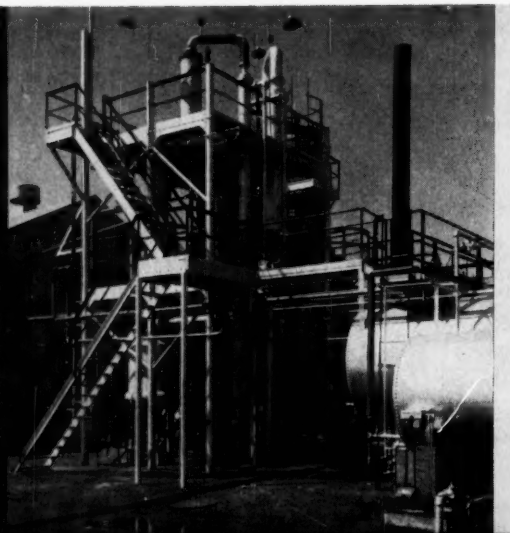
Compressing gas in Near East

Oil refining
in Venezuela

CHAS. PFIZER & CO., INC. uses a vacuum rotary dryer 30 ft. long and 5 ft. in diameter for Terramycin processing at their Groton, Conn., plant.

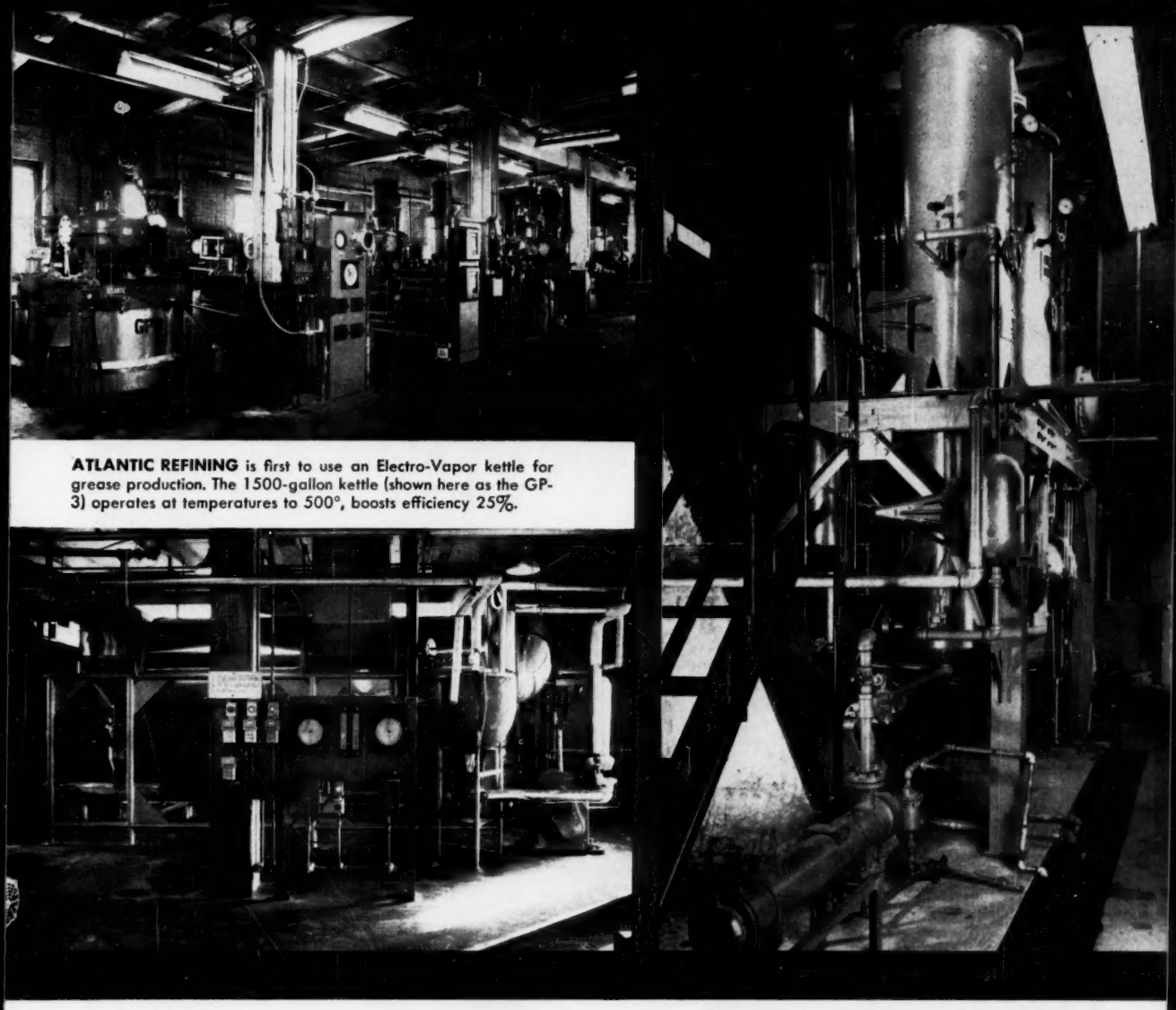
Buflovak processing equipment





Right:
BARECO WAX COMPANY, Division of Petrolite Corporation, uses two single effect, downflow evaporators at Barnsdall, Okla. Shown here: the 235 sq. ft. evaporator.

Left:
PILOT PLANT vacuum double drum dryer is part of modern equipment developed at the Buflovak customer service laboratory — a completely equipped product-process research center.



ATLANTIC REFINING is first to use an Electro-Vapor kettle for grease production. The 1500-gallon kettle (shown here as the GP-3) operates at temperatures to 500°, boosts efficiency 25%.

SEMET-SOLVAY produces powdered polyethylene with a spray cooler. Part of a new technique, this cooling equipment boosts production ten times with little increase in required floor space.

CHANNEL MASTER CORP. recovers cyanide at their Ellenville, N.Y., plant. A double effect, forward flow evaporator processes waste water from a zinc plating operation.

speeds chemical industry progress

Evaporation . . . Drying . . . Solvent Recovery . . . Crystallization . . . Extraction . . . Cooling—whatever your process, Buflovak equipment improves your operation, cuts your costs.

Because the Buflovak line is complete, Buflovak engineers can impartially recommend the equipment proven best for your job. Your own specification and the facts developed from special research provide sure guidance in selecting the right equipment for the job. For unusual problems Buflovak has the engineering and production facilities to build the most complex custom unit.

Sound research, expert engineering, on-schedule delivery, and continuing customer service combine to provide you with superior processing equipment, built to boost your profits. *Send for Catalog 386: "Buflovak Processing Equipment."*

Conduct your research at the Buflovak Lab

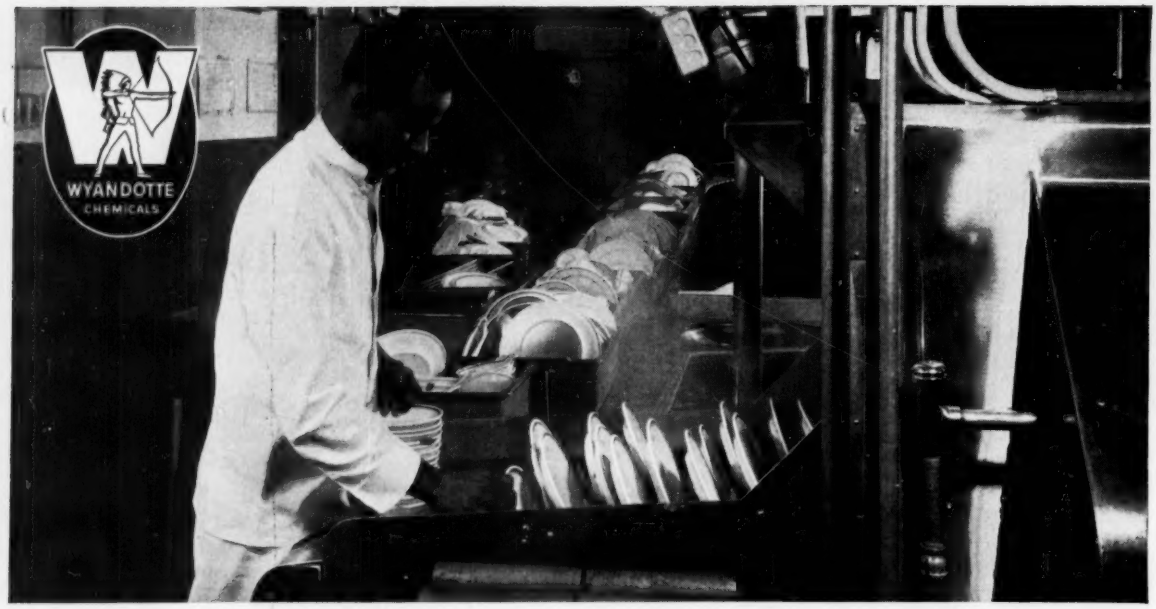
Many progressive chemical companies bring their basic problems to Buflovak. In a completely equipped laboratory they can test a few beakers of material, or run quantity lots on a pilot plant, production scale. Whatever the procedure, positive, practical methods are established. Over 7,500 practical answers have been found here. The Lab is at your service.

BLAW-KNOX

BLAW-KNOX COMPANY

Buflovak Equipment Division

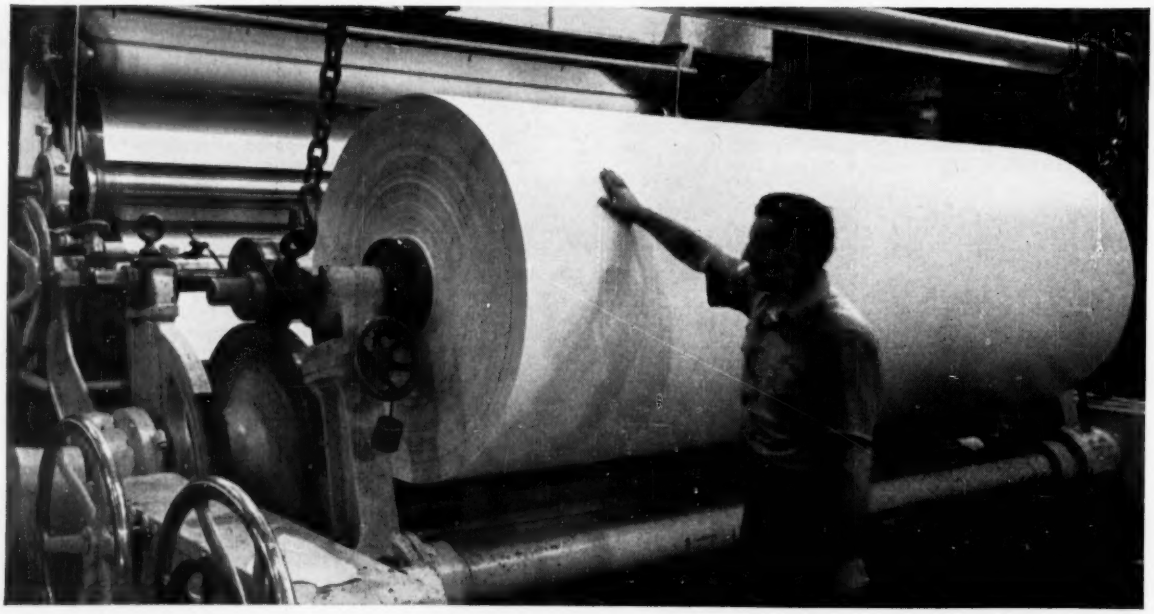
1543 Fillmore Avenue, Buffalo 11, New York



PROBLEM: The presence of milk residue on glasses and dishes can mean trouble in mechanical dishwashing machines. It causes many detergent formulations to foam more than usual.

SOLUTION: The addition of a Pluronic polyol to the formulation exerts a foam-depressing effect on the soap that forms during the washing cycle, resulting in greater washing efficiency.

Can Pluronic® polyols give



PROBLEM: A manufacturer developed an ultrafine talc for use in the manufacture of paper. It passed every test with flying colors except one—it would not disperse satisfactorily.

SOLUTION: Pluronic polyols are excellent dispersing agents. Systematic evaluation using the grid approach enabled chemists to quickly find the best Pluronic grade for their formulation.

PROBLEM: A manufacturer of latex paints wanted to achieve higher pigment loadings. He tried several formulas, but he was unable to keep the viscosity down to the desired level.

SOLUTION: Pluronic L62 effectively reduces the viscosity of highly bodied emulsion paints, permitting higher pigment loadings. Brushing and leveling qualities are significantly improved.

your product new properties?

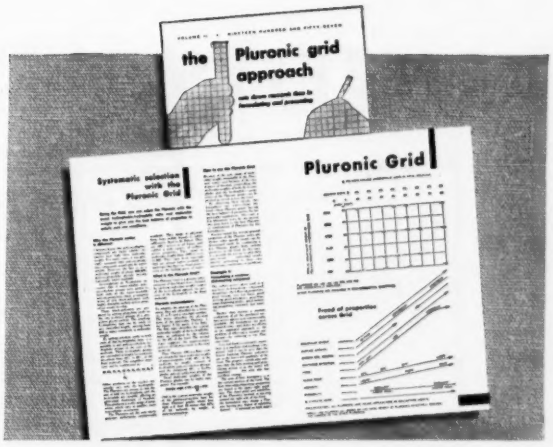
THE ONLY way to find the answer to this question is to evaluate this versatile series of patented block-polymers in your own laboratories. Read why:

Pluronic polyols exhibit a wide variety of surface-active properties. The series ranges in physical form from mobile liquids to solids sufficiently hard to be flaked . . . all forms are 100% active.

Grades in this series have molecular weights as low as 1000 to more than 11,000. They vary from materials that are almost water insoluble to materials that have no cloud point—even at the boiling point of water.

These pictures show three typical uses of the Pluronic polyols. Actually, over 100 practical applications have been found so far, and the end is not in sight!

Don't these facts suggest areas you would like to explore? For samples, technical data, and your copy of the Pluronic Grid, write us today. *Wyandotte Chemicals Corporation, Department 783-E, Wyandotte, Michigan. Offices in principal cities.*



The famous Pluronic Grid provides a controlled, systematic method of screening . . . minimizes costly random investigation and evaluation by establishing related property trends between the grades available.

Wyandotte CHEMICALS MICHIGAN ALKALI DIVISION

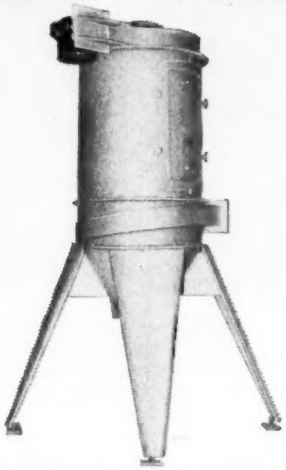
Pacing progress with creative chemistry

SODA ASH • CAUSTIC SODA • BICARBONATE OF SODA • CALCIUM CARBONATE • CALCIUM CHLORIDE • CHLORINE • MURIATIC ACID • HYDROGEN • DRY ICE
GLYCOLS • SYNTHETIC DETERGENTS (anionic and nonionic) • SODIUM CMC • ETHYLENE OXIDE • ETHYLENE DICHLORIDE • POLYETHYLENE GLYCOL • PROPYLENE OXIDE
PROPYLENE DICHLORIDE • POLYPROPYLENE GLYCOL • DICHLORODIMETHYLHYDANTOIN • CHLORINATED SOLVENTS • OTHER ORGANIC AND INORGANIC CHEMICALS

PROBLEM: How to efficiently convey

SOLUTION: *Fluidizer® Air*

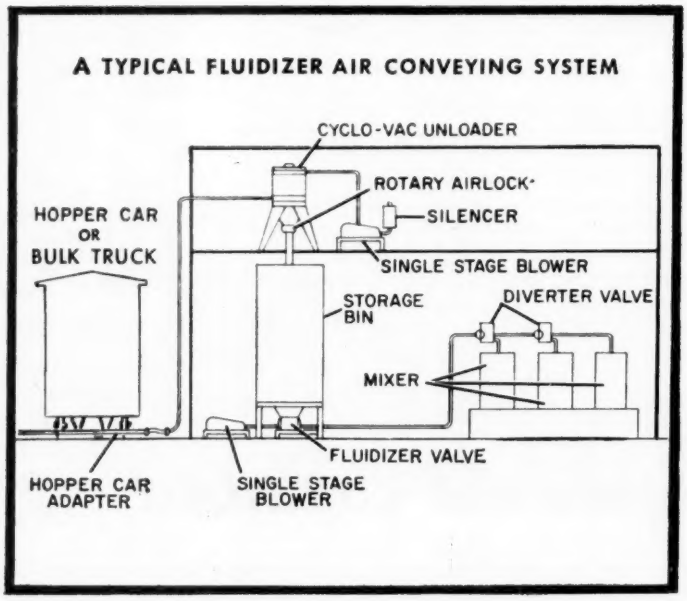
Air convey powder or granular chemicals anywhere in your plant—automatically . . . through completely sanitary pipelines. A Fluidizer air conveying system will slash handling costs, enable you to save with bulk deliveries, release extra floor space for new uses, and make your bulk conveying an efficient "push-button" operation.



"CYCLO-VAC"® CAR UNLOADER. Air unload bulk railcars or trucks up to 1000 lbs. per minute. Completely sanitary . . . up to 99.9+% recovery of even the finest materials. No dust collectors needed.

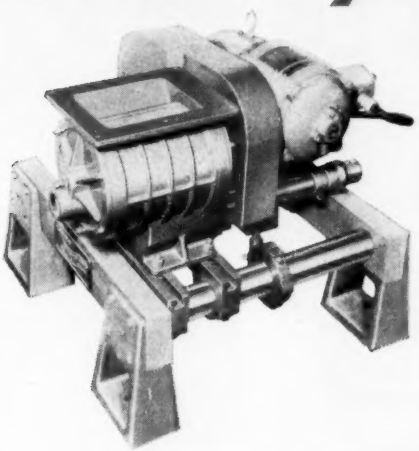
BENEFITS:

- No contamination • Cuts handling costs
- Low maintenance — a minimum of moving parts

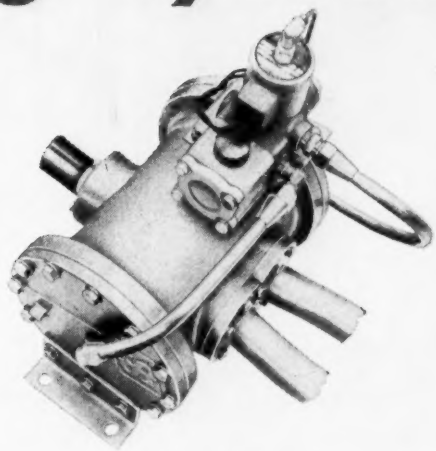


Powder or Granular Chemicals

Conveying Systems



"FLUIDIZER" — the most efficient air conveying valve produced. Sizes and capacities to fit your needs. Closely machined tolerances and rugged construction mean low maintenance. Low power requirements. Line sizes — 1½" to 4" (I.D.).



PISTON-TYPE FLOW DIVERTER. Switch air conveying lines instantly "on stream." No jamming problems . . . activated by compressed air. All metal — no rubber sleeves. 4 sizes.

- Stops waste and dust • Your savings quickly pay for equipment.
- Complete flexibility and adaptability • Automatic, "pushbutton" operation

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Bakelite (*powdered and coarse*)	Glue (*powdered*)	Magnesium Hydroxide	Soda Ash (*light and dense*)
Borax Powder	Graphite Flour	Magnesium Oxide	Sodium Phosphate
Calcium Carbonate	Gypsum	Plastic Pellets	Sulphur (*powdered*)
Carbon (*activated*)	Kaolin Talc	Polyethylene Pellets	Talc
Catalysts	Kralac	Polyethylene Powder	Talcum Powder
Cellulose Propionate		Polymer Powder	Vinyl Plastic
Coke Flour			Wood Flour
Diatomaceous Earth			2-4-D

*Partial list—write for complete engineering data

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NEW BAILEY
Multi-Pointer Gage

...has twice as many indicators
...no taller than a telephone!

Now the popular versatile Bailey Multi-Pointer Gage has been reduced in size to conserve control panel space—without loss of easy *readability*.

Each new Multi-Pointer Gage Unit offers you these three choices to—

1. Measure and indicate draft, pressure, differential pressure and level.
2. Transmit above variables either pneumatically or electrically to remote indicators, recorders and/or controllers.
3. Receive and indicate any measured variables which may be transmitted pneumatically by standard SAMA ranges of 3-15 psig. or 3-27 psig.

FEATURES

Compact Size—Two large, easily-read 7″ scales in space only 4 inches wide.

Wide Range Selection—Standard ranges from 0-0.5 in. H_2O to 0-5000 psig available.

Choice of Standard Colors—Satin Black, Slate Gray, Moss Green, or Terra Tan may be selected as an exterior color at no additional cost.

Colored Scales—Scales available in white, red, green, blue, yellow, or orange.

Fluorescent Illumination—All gages have slideout unit containing bulb and starter for ease of maintenance.

Readily Accessible Adjustments—Zero adjustment made from front of gage. Other adjustments made from rear of gage.

Two-point Positive Mounting—Gage unit mounted with two clips . . . no holes to drill or studs to weld.

Unlimited Indications—Any number of basic two-indicator units may be placed side-by-side to provide indications of related factors. Each two-indicator unit is separately mounted.

For additional information, call your local Bailey District Office, or write us direct.

CP3-1

Chemical and petroleum division

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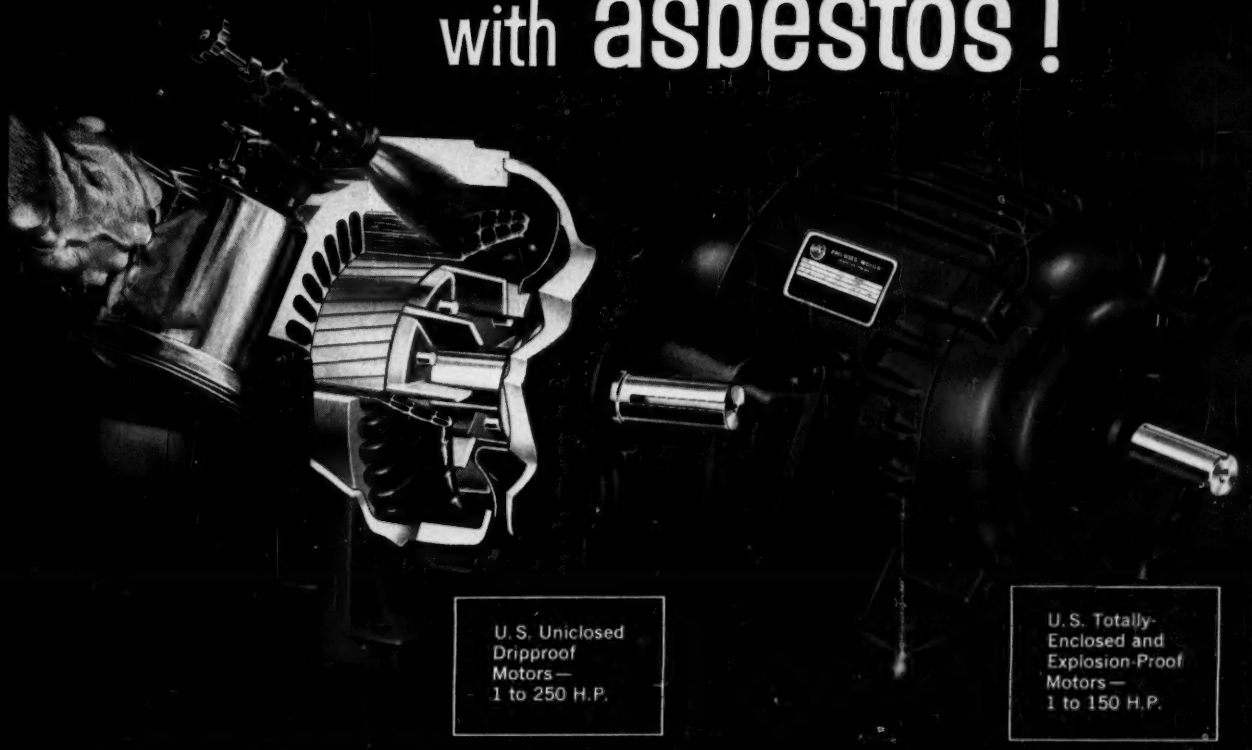
In Canada—Bailey Meter Company Limited, Montreal

only U. S. MOTORS

with asbestos!



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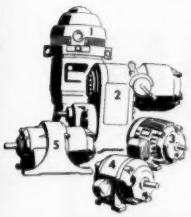
U. S. Totally-Enclosed and Explosion-Proof Motors— 1 to 150 H.P.

your best protection against motor burn-out and production shut-downs

Only U. S. offers this protection! ALL windings insulated with asbestos—nature's million-year-old insulating material that *cannot carbonize!* Many motor makers use varnished paper, cloth, oiled linen, pressboard, fish-board—even insulating varnish alone. All these will carbonize... not one is fire-proof!

Only the original, patented U. S. Asbestic Process—gives you: 1—*heat resistance*... can't carbonize, 2—*heat conductance* better than any cellulose material, 3—*moisture resistance*... due to exceptional impregnation and coating of all motor windings. Protect against costly production stoppages due to motor burn-out! Specify: "U. S. Motors"!



U. S. ELECTRICAL MOTORS INC.

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U. S. MAJOR MOTOR LINES INCLUDE:
1. Vertical Solid & Holloshaft, 2. Varidrive, 3. Totally-Enclosed, 4. Uniclosed, 5. Syncrogear. Also, many other special motors.

FREE COLOR-ILLUSTRATED BROCHURES...
For specific data on asbestos protection, write for General and Type H Uniclosed Bulletins.

There's a big difference in PAYLOADER® performance

Big Load Capacity The model H-25 "PAYLOADER" tractor-shovel has a carry capacity of 2,500 lbs. — carries more for its weight than any machine in its class.

More Digging Power Breakout force of 4,500 lbs. is available at the bucket cutting edge — more than on any machine near its size. Exclusive power-transfer differential makes traction and "crowding" power more positive, especially when traction conditions are slippery.

More Maneuverable Shortest turning radius (only 6 ft. at rear wheel hub) and power-steer make it possible to operate in closer quarters with greater speed and safety.

Power-shift Transmission The model H-25 is the only machine in its class having a full-reversing power-shift transmission with two speed ranges forward *and* reverse — the low ranges for digging power and close maneuvering, the high ranges for fast, economical travel. All "clutching" and gear-shifting is eliminated.

Lower Maintenance The boom and bucket mechanism is of rugged, simple design with fewer parts and linkages. Quality materials are used throughout, including anti-friction bearings at critical pivot points.

Longer Life The most complete system of protection has been engineered into the Model H-25 to insure long life and freedom from trouble: triple air cleaning system for the engine; cartridge-type filters for all three oil systems; self-adjusting, sealed hydraulic brakes; closed, pressure-controlled hydraulic system; grease and oil seals on all pivots and ball joints.

Your Hough Distributor is another reason why you'll get lower-cost-per-ton bulk material handling from a "PAYLOADER". He is ready to give you full information on the H-25, or larger models up to 12,000 lb. carry capacity.

THE FRANK G. HOUGH CO., 754 Sunnyside Ave., Libertyville, Ill.

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7-A-1

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THE FRANK G. HOUGH CO.
LIBERTYVILLE, ILLINOIS
SUBSIDIARY — INTERNATIONAL HARVESTER COMPANY

Dateline: Formosa

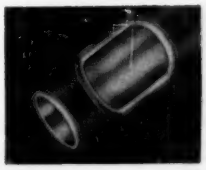
Bridgeport Duplex Tubes Solve a Chinese Corrosion Puzzle

The recently completed urea plant for Taiwan Fertilizer Company, Ltd., on Formosa, will increase fertilizer production so necessary to the Chinese Nationalist agricultural economy. Designed according to the Inventa-Vulcan process, the urea synthesis section of the huge installation utilizes a number of specially designed heat exchangers in various processing steps.

One of the many problems that had to be faced was to find a heat exchanger tube capable of meeting the combined corrosive attack of both the cooling water and the process stream. The natural corrosive qualities of water in the raw state were heightened by the periodic injection of chlorine to kill living organisms. The process fluid, on the other hand, presented an entirely different set of problems. No single alloy could cope with both corrosive media. As is often the case in such circumstances, the solution was found in Bridgeport Duplex Tubes made by drawing two different alloy tubes to form one mechanically bonded bimetal tube.

The effectiveness of Bridgeport Duplex Tubes in such applications as chemical processing, refineries and food processing, is as widespread as their use. They are available in a wide variety of alloy combinations to meet virtually any corrosive problem.

For full details, call your nearest Bridgeport Sales Office or write direct for the new BRIDGEPORT DUPLEX TUBE MANUAL. Dept. 5007



Bridgeport Duplex Tubes are bimetal tubes—two tubes combined into one. With them, you can select the metal alloy surface best suited to meet the corrosive attack to which it is exposed.

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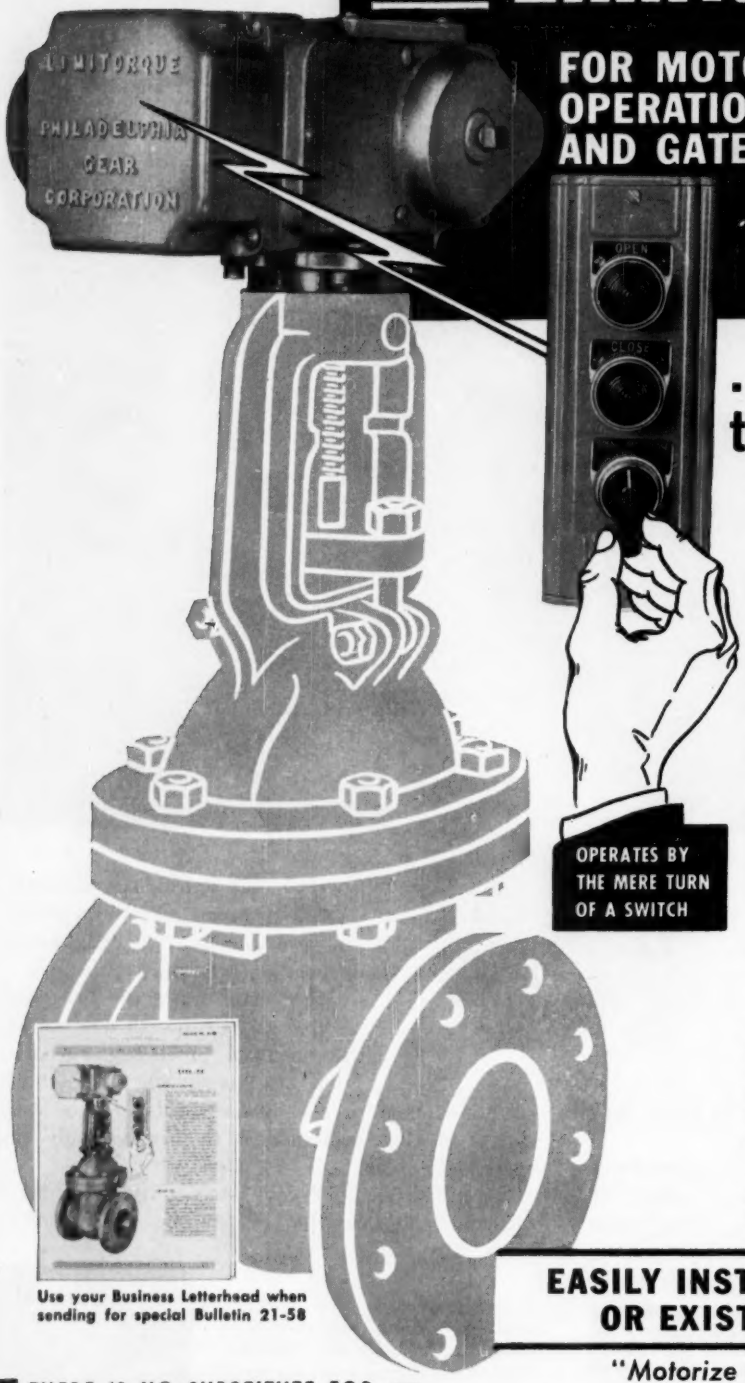
New LimiTorque

TYPE P-2

FOR MOTORIZED AUTOMATIC OPERATION OF SMALL GLOBE AND GATE VALVES

. . . Economically and Efficiently



OPERATES BY THE MERE TURN OF A SWITCH

. . . truly a dependable time and money saver

Here is a new, compact, economical and dependable LimiTorque Motorized Operator for use on small (normally hand-operated) Globe and Gate Valves — either new or already in service. Your existing hand-operated valves can now be easily motorized by the removal of the hand-wheel, and mounting the P-2 Unit on the same bonnet . . . the Unit output drive sleeve will then drive the hand-wheel unit, which arrangement is suitable for both rising and non-rising stem valves.

The P-2 LimiTorque Operator has a standard out-put speed of 22.5 or 45 rpm, which covers the average and recommended operating speed for most Globe and Gate Valves.

Remember, this new P-2 LimiTorque is built by the largest manufacturer of Motor Operators for Valves in the World . . . backed by nearly 30 years experience.

BE CONVINCED how the P-2 can save you time, labor and money in the operation of small valves — just write for Bulletin No. 21-58, which not only illustrates and explains its operation, but shows how easily it can be installed on existing or new valves.

Contact your Valve Manufacturer, or your nearest LimiTorque Sales Engineering Office.

Use your Business Letterhead when sending for special Bulletin 21-58

EASILY INSTALLED ON NEW OR EXISTING VALVES

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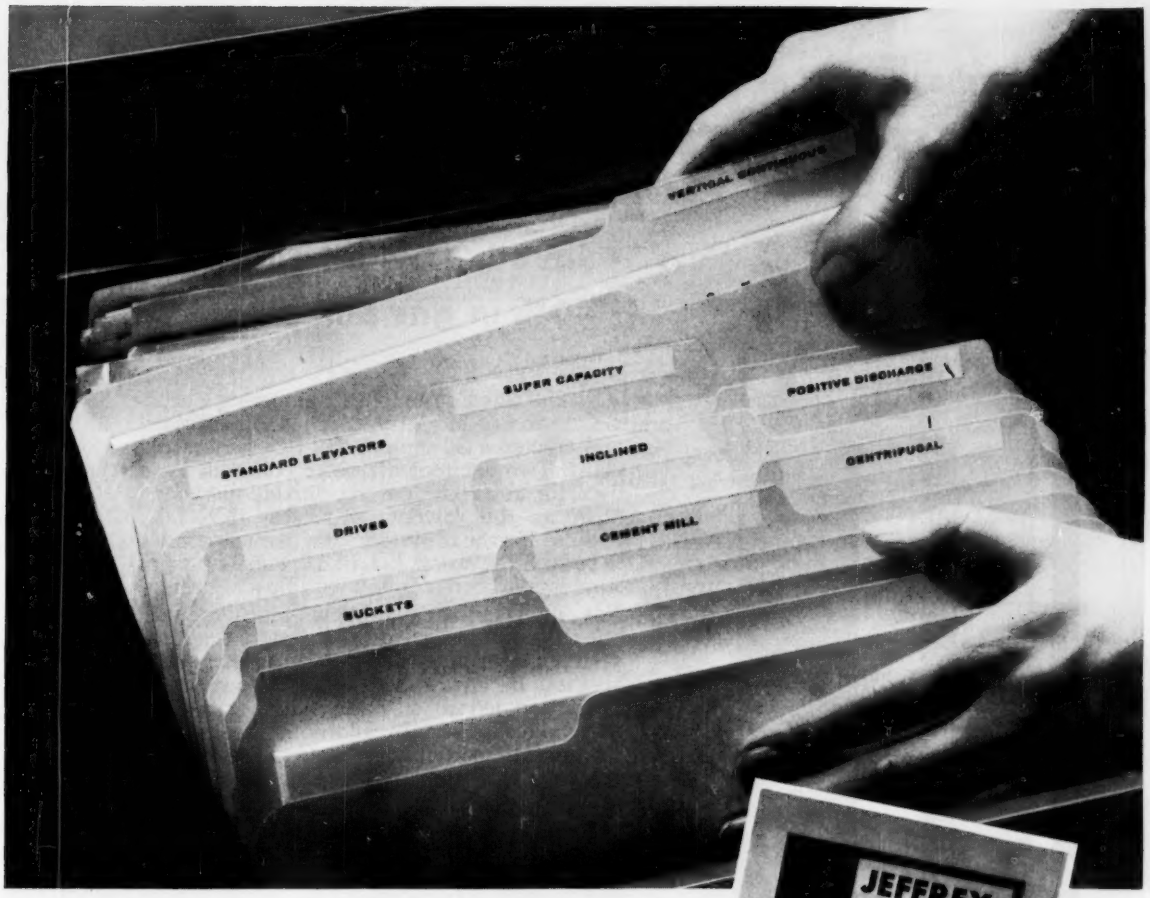
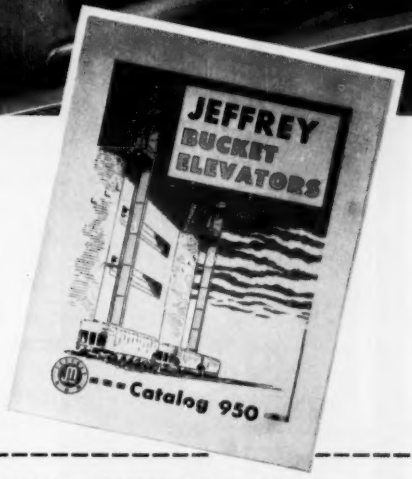


Have complete Jeffrey bucket elevator facts at your fingertips



Jeffrey offers a complete range of bucket elevator systems and components for elevating bulk materials from fines up to 8 inch lumps. You can have complete facts at your fingertips by sending now for this new 96-page catalog complete with types, weights, dimensions and capacities.

This catalog can simplify your planning of elevating systems – and ordering standard replacement parts for fast delivery. Use coupon for your free copy. The Jeffrey Manufacturing Company, 909 North Fourth Street, Columbus 16, Ohio.

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In the design of these MEA Absorbers and Strippers

INTALOX SADDLES

- **Saved 20% in height**
- **40% in gas pumping costs**

GEECO

The Gas Equipment Engineering Corporation of Mount Vernon, N. Y. designed and erected a 30 ton-per-day CO_2 generating plant. Two six foot diameter columns were used for absorbing carbon dioxide gas using MEA as the solvent. By using INTALOX Saddles for the tower packing, it was possible to reduce the tower height 20% below what would have been required with Raschig Rings.

Not only was the capital cost greatly reduced but the columns performed even better than design requirements. Operating costs were also less because the appreciably lower pressure drop led to a 40% reduction in gas pumping expense. In addition, the greater-than-design scrubbing efficiency led to increased CO_2 recovery.

In mass transfer operations involving packed towers the use of Intalox Saddles almost invariably means increased capacities, lower pressure drops, and, of course, lower initial and operating costs.

U. S. STONEWARE

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OUR 100th YEAR

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INTALOX SADDLE PACKING

Would you like to know more about INTALOX SADDLES? Write for Bulletin S-29R

388-F

DEVELOPMENTS . . .

JUNE 29, 1959

Chementator

C. H. CHILTON

Polybutylene is newest isotactic polymer to reach pilot plant, reports Montecatini. Among U. S. firms, Spencer is actively looking at polybutylene, but work is still in the laboratory stage.

Caprolactam will be made via photosynthesis in a new plant in Armenia. Process involves exposure of cyclohexane and nitrosyl chloride to radiation, according to a German report.

General Electric's corner on polycarbonates in the U. S. is not expected to last very long. Mobay's plans for a plant are in an advanced stage.

Ultra Chemical, Paterson, N. J., becomes second U. S. processor to buy a Chemithon continuous sulfonation plant. Lever Bros.' 25-million-lb./yr. plant in Los Angeles is now fully on stream.

Sand-cracking produces ethylene

Noncatalytic fluid cracking, using sand as a circulating heat-transfer medium, is a feature of a new ethylene-propylene process.

First commercial plant using this process was put on stream recently in Germany by Erdoelchemie GmbH., Dormagen, a joint subsidiary of Farbenfabriken Bayer and British Petroleum. Capacity is 20,000 tons/yr. of ethylene, or a total of 35,000 tons/yr. of C_2-C_4 olefins.

Process resulted from joint efforts of Lurgi Gesellschaft fuer Waermetechnik, Frankfurt, and Ruhrgas AG., Essen, in cooperation with Bayer.

Versatility with respect to feedstocks and operating conditions marks the LR process. Conventional steam-cracking of hydrocarbons, widely used for olefin manufacture in Europe, must use feedstocks boiling under 160 C. and must operate at moderate cracking temperatures. Higher-boiling feedstocks and/or high cracking temperatures impose the danger of increased coke deposits in the tubes.

The new sand-cracking technique can handle a wide range of feedstocks, from LPG to heating oil. And coke deposits are easily taken care of via an FCC-type of regeneration step which supplies the endothermic heat of reaction as well.

Ratio of propylene to ethylene in the product gas can be varied over the range 0.3-0.8 without reducing the optimum yield of total olefins, says Lurgi.

New filter saves Pt catalyst

Loss of platinum-rhodium catalyst has always been a limiting factor on operating temperature in ammonia oxidation plants—and thus has limited yields of nitric acid.

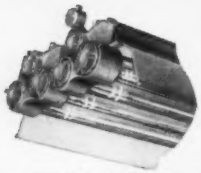
Now Oesterreichische Stickstoffwerke AG., Linz, Austria, claims that a simple filter of ordinary lime will recover 60-88% of the vaporized platinum at 1,380-1,580 F., allowing

For Modern, Hazardous Area Lighting...

Type "EFU" Explosion-Proof 3-Lamp Fluorescent Lighting Fixture

APPLETON®

"EFU" Explosion-Proof Fluorescent

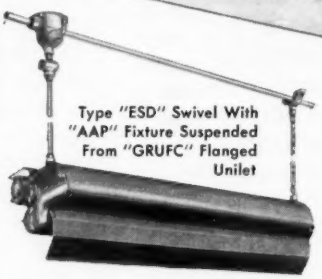


Type "EFU" Explosion-Proof 4-Lamp Fluorescent Lighting Fixture

Patent No. 2,392,202 and Pat. Pending

CHECK THESE FEATURES

- Factory sealed for easy, trouble-free installation
- Available in: Pre-Heat Bi-Pin; Rapid Start Bi-Pin; Instant Start Single Pin Slimline
- Less than 12" required between canopy unilet and fixture
- 45° or horizontal mounting
- "Rapid Start" ballasts where desired for longer lamp life, no flicker, quiet operation, no starters and long ballast life
- Steel reflectors, white enameled inside . . . grey outside



Type "ESD" Swivel With "AAP" Fixture Suspended From "GRUFC" Flanged Unilet

Introduces flexibility in suspension of single unit lighting fixtures in hazardous locations. Meets National Electric Code Article 500.

■ Yes, APPLETON "EFU" Fixtures are factory sealed and so perfectly designed and superbly built they eliminate the need for external seals normally required within 18 inches of arcing devices as specified in Article 500 of the National Electric Code. Available in 2, 3, or 4 lamp models for straight or angle mounting, with "Pre-Heat," "Slimline" or "Rapid Start" ballasts. All models have cast aluminum end housings with line connectors to terminal block. Fixtures may be installed as a single unit or in a continuous row. Re-lamp from either end. Swivel unions are available for fixture flexibility that allows quick re-lamping in tight places. Write for wattages, types of fixtures or complete specifications.

APPLETON® Lighting Fixtures are available in non-fluorescent and fluorescent as well as a wide variety of non-explosion-proof and explosion-proof styles. Special shelf, bin and high bay illumination numbers. Write to us stating problem.

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APPLETON ELECTRIC PRODUCTS®

Also Manufacturers of:

Malleable Iron Unilet Fittings

"ST" Series Connectors

"Eagle Claw" Switch Boxes

Reelites

operators to boost temperatures and yields.

Present practice in most U. S. nitric plants is to insert a glass-fiber filter in the line leaving the converter. Platinum trapped in these filters is returned to the catalyst maker for credit.

Since the cost of ammonia constitutes such a large fraction (around 70-75%) of the cost of making nitric acid, even one percentage point higher yield means real savings. So if you have an economical way of recovering most of the platinum vaporized at a higher operating temperature, you get higher conversions without sacrificing the catalyst.

New filter consists of a layer of commercial calcium oxide about 2½ in. deep suspended on a wire-mesh sieve. One ton of lime will recover up to 6.5 lb. of platinum and rhodium and will be effective for a year. After filter removal, lime is dissolved in water and then treated with nitric acid prior to recovery of the precious metals.

Who really controls your know-how?

While property rights in trade secrets and engineering know-how are well established as a point of law, the federal government is now exerting a right of eminent domain over such private property unusual for peacetime conditions.

Bulletin 814, a new Commerce Dept. ruling effective this month, puts tougher restrictions on export of unpublished technical know-how relating to certain petroleum refining and chemical processes. The list includes 15 processes such as alkylation, hydrogenation, reforming and nitration.

The government has exercised control over export of know-how for the past ten years, presumably throttling flow of technical data to the Soviets. Under the new rules, however, you cannot export data on the specified processes even to non-Soviet countries unless you show evidence that neither the data nor the primary product of that data is intended to be transshipped to a Communist destination.

This action is stirring up a storm, with contrary arguments such as these:

• With no way of forcing the non-Soviet chemical or petroleum processor to live up to any agreement for an indefinite period, the U. S. exporter runs the risk of $10,000 fine and one year imprisonment.

• Other Western nations—notably Britain, France and West Germany—are eagerly filling Soviet orders for chemical process know-how and equipment. "It looks like we're locking the barn door with one horse inside and the rest out in the meadows," comments one skeptical observer.

• In many other important areas of technology there are no such restrictions. In the case of heavy water technology, for example, inventor Jerome Spevack had to go all the way to the Supreme Court to keep AEC from giving the whole world his secret process, free of charge (*Chementator*, April 20, p. 73).

U. S. engineers can thank such groups as Manufacturing Chemists' Association for the new ruling. MCA has insisted that it would be a grave mistake to sell chemical know-how to Russia. "We must realize that technical advantages are among our most precious possessions," says MCA President John Hull, "and they must not be traded away."

Commerce Dept. is apparently relying on patriotism of American industry to make its controls effective. Engineers interviewed by *CE* generally agreed with the government's objectives in keeping valuable technology out of Soviet hands and that, no matter how troublesome, we will learn to live with the new regulations.

What's new in porous plastics

Porous sheet materials figure in two new developments in plastics this month:

• A permeable high-density polyethylene sheet of medium pore size has been introduced in England for use as a filtration medium, electrolytic diaphragm, air diffuser (for fluidized-solids conveying) and medical casts.

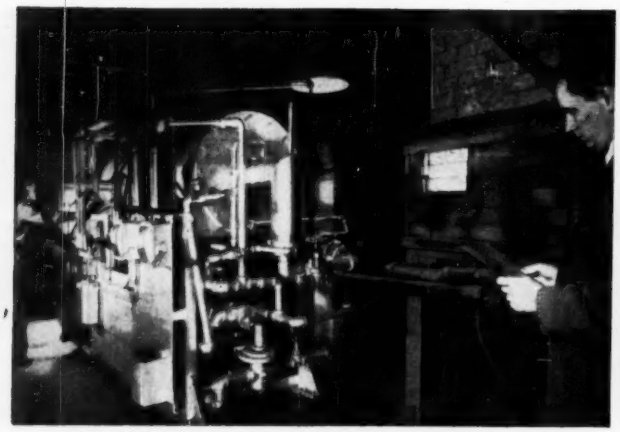
• Plastic sheets with extremely fine pores are being commercialized in the U. S. for a wide variety of uses where controlled, uniform microporosity is a virtue. Such products can be used for filtration without filter aids. Because they can be made permeable to gases but impermeable to liquids, they can be used for "breathing" rainproof garments.

Making the latter materials at Buena Vista, Va., before year's end will be ESB-Reeves Corp., a newly formed affiliate of Electric Storage Battery Co. and Reeves Bros. Corp. ESB brings to this marriage its patented

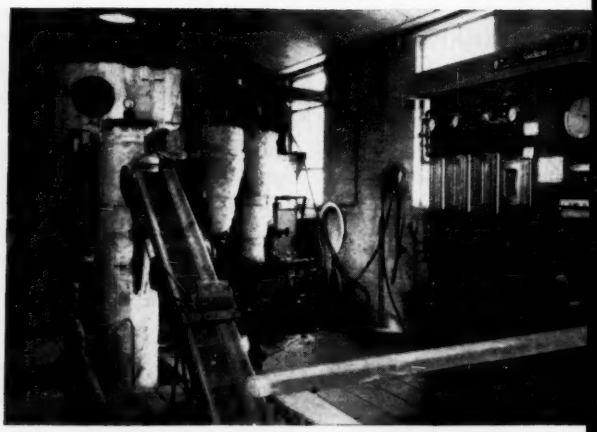
(Continued on page 42)

DORR-OLIVER offers . . .

A COMPLETE LABORATORY AND PILOT PLANT TESTING SERVICE FOR THE FLUOSOLIDS

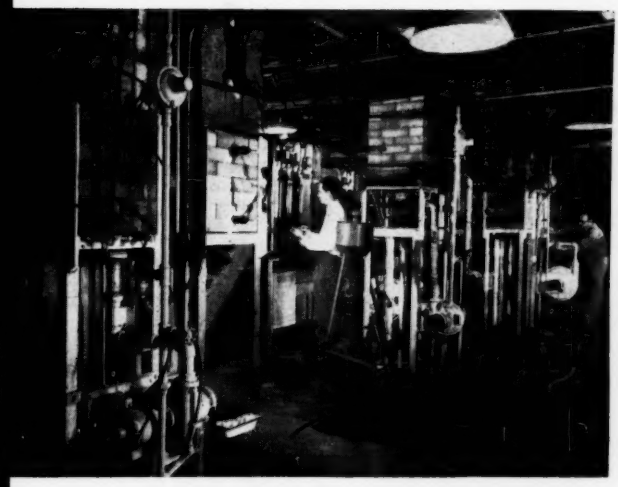


FLUOSOLIDS 12" I.D. STAINLESS STEEL REACTOR, inside insulating brick chimney at right, is shown with reducing gas generator (left). This installation provides for accurate evaluation of either oxidizing or reducing reactions.



FLUOSOLIDS PILOT PLANT DRYER installation includes 12" I.D. reactor, instrument panel, belt conveyor feeder and scrubber (in background). Also in background, but not part of the dryer system, is the electrostatic precipitator used for the 12" FluoSolids Roasting Reactor.

LARGE PORTABLE PILOT PLANT can be disassembled and shipped to any location for on-the-spot operation in the final stages of certain specialized testing and development programs involving one or two stage operation.



SIX FLUOSOLIDS LABORATORY REACTORS, with 4" I.D. reactor tubes of stainless steel or silicon carbide, installed at D-O's Westport research center. Photo shows lower sections of reactors and part of insulating brick chimneys, with gas heating systems and instrument panels.

SYSTEM

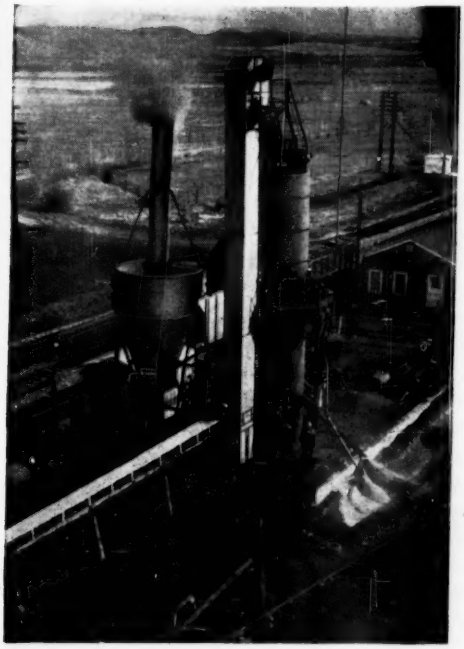
. . . today's most versatile drying, sizing and heat treating technique for the chemical industries

The FluoSolids system offers a highly versatile method of drying, sizing, roasting and heat treating a wide variety of ¾" to 325 mesh solids using the principle of solids fluidization. It is adaptable to precise temperature control, offers high capacity with equipment of minimum size and is particularly suitable for processes requiring continuous-line operation. A broad range of applications is possible in the chemical industries.

At Dorr-Oliver's research and development center, Westport, Connecticut, complete facilities are available for laboratory testing and pilot plant demonstration. Feasibility of FluoSolids techniques and the economics involved can be analyzed and determined. From pilot plant operations, the results of full scale commercial application can be accurately predicted. With the use of other Dorr-Oliver equipment which is also available, test set-ups can be made of a complete processing operation.

Hundreds of test runs already made indicate successful application in such operations as drying of heat sensitive polymers, hydrochloric acid and sodium sulphate production by the Hargreaves Process, drying of sodium chlorate crystals and potassium silicon fluorides, drying of chemical precipates, roasting of furfural residues, and low temperature calcination of phosphates. Opportunities for further development are far from exhausted.

If you are interested in the potentialities of solids fluidization techniques, Dorr-Oliver engineers will be glad to discuss your problems and to suggest possible arrangements for analysis and development. An inquiry costs nothing—and it may prove mutually rewarding.



FluoSolids—T.M. of Dorr-Oliver Incorporated, Reg. U. S. Pat. Off.

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process by which it has for some years made microporous polyvinyl chloride battery separators. In this process a thermoplastic (almost any one) can be endowed with pores of unparalleled uniformity and fineness—1 to 10 microns. In comparison, finest size of pores in foamed plastics is 200-300 microns; pore size of nonwoven fabrics is in the range of 100-200 microns.

ESB mixes softened thermoplastic with starch of selected particle size. Rice starch gives pores of 1-5 microns; corn starch, 5-10; potato starch, 20-30, etc. Mix is extruded, calendered or spread-coated to desired shape. Shaped material goes into boiling water. Each starch particle gels, expands by 40% and ruptures its plastic containing wall. Starch is leached out with sulfuric acid, leaving a finely channeled plastic.

The British material is made by sintering finely ground polyethylene on a moving belt under infrared lamps. Product has pores of 100-200 microns. Manufacturers are Pritchett & Gold and E. P. S. Co. Ltd., London.

Sintering lends itself to other thermoplastics, and several U. S. companies, including ESB-Reeves, are playing around with it. Coarser and friable rather than flexible, sintered plastics aim at a different set of applications than their starch-formed cousins.

New rubber resists nuclear radiation

An unheralded type of specialty rubber, not yet in commercial production, is key to a recent proposal by Goodyear to the Navy for construction of a nuclear-powered blimp.

The new material, called an "adduct rubber," is made by adding methyl mercaptan to polybutadiene or other diene rubbers. The mercaptan reacts with the polymer latex at 30-60 C. with the help of a free-radical initiator, such as bis-azo-isobutyronitrile. Goodyear has made pilot-plant quantities of adduct rubbers for large-scale testing.

These rubbers, says Goodyear, are extremely resistant to oxygen, ozone and weathering, show low gas permeability and—important for the proposed nuclear blimp—are more resistant to degradation by nuclear radiation than any other elastomer. The airship would be made of a rubberized Dacron fabric which could withstand exposure up to 100 million roentgens.

Adduct rubbers with saturation levels as high as 85% can be cured with the same procedures used for the base polymer. Higher levels require an "activated" cure of the type used for butyl rubber.

Future cloudy for fluid-bed iron

Direct reduction of iron ore in fluid beds is running into steadily stiffening competition from established iron and steel processes. Continuing technological improvements in blast furnaces and steel furnaces throw a shadow over direct reduction's once promising future.

This is the opinion expressed to *CE* by David McBride, United States Steel's director of metallurgical process development. It explains why USS has begun soft-pedaling its development of the Nu-Iron fluid-bed process.

McBride states that the Nu-Iron process has been completely proved out in pilot plant. The company recently projected pilot-plant data up to a full-scale, 2,000-ton/day commercial unit. Results of this study, says McBride, clearly showed that the Nu-Iron process wasn't economically competitive today. Key problem seems to be relatively high cost of the fluidizing gas—hydrogen or carbon monoxide.

Sandwich cells produce superpure Al

Aluminum of extreme purity will be available in greater quantity this fall when Kaiser triples its capacity for producing metal of 99.99% quality.

Installation at Mead, Wash., of two new three-layer refining cells—claimed to be among the largest of their type in the world—will up Kaiser's capacity for making superpure aluminum to about 900,000 lb./yr.

Demand for this product is burgeoning. Major applications include petroleum catalysts, foil for electrical capacitors and manufacture of costume jewelry. Cultivating these markets, Kaiser and Reynolds both announced last year the availability of 99.99% ingots in addition to the usual pellet form.

Pechiney, French aluminum producer, claims an analysis of "five nines" (99.999%) for its superpure product. And the Russians say they have made aluminum of "seven nines" purity in the laboratory, expect to make it semicommercially.

All superpure aluminum is made electrolytically in some variation of the Hoopes three-layer refining cell. Bottom (anode) layer is a heavy molten mixture of aluminum and cop-

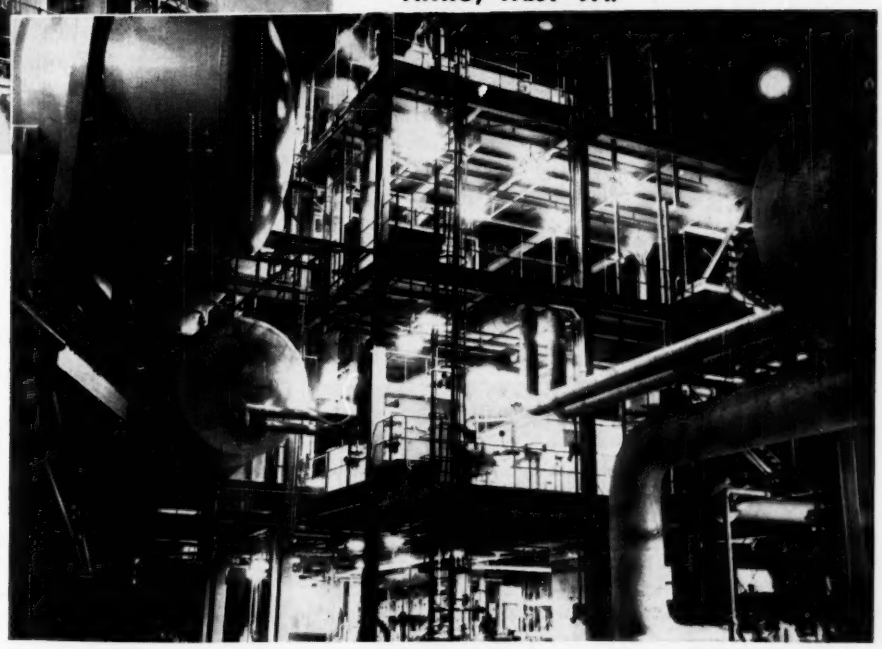
1

NORTH CLAYMONT, DEL.

BATON ROUGE, LA.

NITRO, WEST VA.

2



3

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First North Claymont, Del. . . . then, Baton Rouge, La. . . . now Nitro, West Virginia! General Chemical is now supplying anhydrous HF to its customers from *three* producing works and aqueous HF (tank cars and drums) from an additional *five* company-owned locations. These five aqueous HF bulk storage and packaging stations are located at Buffalo, N.Y.; Chicago, Ill.; Cleveland, Ohio; El Segundo (Los Angeles), Calif.; and Pittsburgh, Pa.

Here is a three-way producing source and an eight-point supply line that you can rely on for your HF requirements. Each backs up the other, assuring service and availability at all times, under all conditions.

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Allied Chemical's General Chemical Division is America's primary producer of hydrofluoric acid and the *only* supplier offering shipment from more than one producing location. Also important to you are General Chemical's extensive resources for essential raw materials—your best protection against interruptions of supply. General owns a large number of fluorspar mines and operates its own mills . . . and, of course, a broad network of sulfuric acid plants. That's why it's wise to make General *your HQ for HF!*

Basic to America's Progress

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GENERAL CHEMICAL DIVISION

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per. On top is the cathode layer of pure aluminum.

In between is a molten salt electrolyte whose composition and temperature vary. Pechiney uses aluminum fluoride, sodium fluoride and barium chloride and a cell temperature of 750 C., whereas the conventional Hoopes bath is 60% cryolite and 40% barium fluoride, with a cell temperature of 950-1,000 C. The Swiss Aluminum Industrie AG. uses fluorides of aluminum, sodium, barium and calcium.

Reynolds licenses the Pechiney process, with six refining cells in operation at Listerhill, Ala. Kaiser is thought to use the Swiss version. Alcoa does not at present produce superpure aluminum, importing its needs.

Tomorrow's Technology

Today's embryonic developments which have special significance for chemical engineers

Rocketeers explore new markets

Chemical manufacturers and engineers involved in the field of rocketry are eagerly seeking new outlets for their products and energies to supplement the mercurial missile business.

Rocketdyne (division of North American Aviation) proposes use of small rocket engines as auxiliary propulsion units on commercial aircraft. Extra power for takeoff, while important, is only one expected benefit. Added range, load-carrying ability and safety would also result.

The company has developed for this purpose a series of off-the-shelf liquid-fueled engines using high-strength hydrogen peroxide. They have already been flight-tested, but further testing is needed to win CAA approval.

Rocketdyne evolved these engines under a Navy contract. A rocket engine on a carrier-based jet plane could provide instantly available power to get the plane airborne again in event of a waveoff or failure to engage the arresting gear. Jet engines, in contrast, have a comparatively long reaction time.

Surface use of rocket engines is the aim of Reaction Motors (division of Thiokol). Initial applications will be in catapults for launching carrier planes. First launchings were made last month by a land-based demonstration unit at Lakehurst, N. J. RM is now building four units for the Enterprise, the Navy's first nuclear-powered carrier.

The catapult rocket burns JP-5 jet fuel in 1,500-psi. air. Water is injected into the hot combustion gases to cool them to 600 F. while adding to the gas volume. Launching capacity is 50% greater than existing steam-powered catapults, says RM.

Machine Sources Show *Lower Costs*

	Isotopes	Machines
Energy output, kw	30*	15–30
Investment, $1,000/kw	130–350	4–10
Operating cost, $/kwh	3–4	0.5–1.0

* Equivalent to 2 million curies of Co-60.

Brighter prospects for radiation

New, more powerful electron accelerators, represented by the right-hand column in the table above, promise to bring the cost of radiation energy down to a level calculated to encourage widespread commercial radiation processing of chemicals and plastics.

Especially significant is the big cost advantage these machine sources now show over radioisotopes such as cobalt-60 and cesium-137.

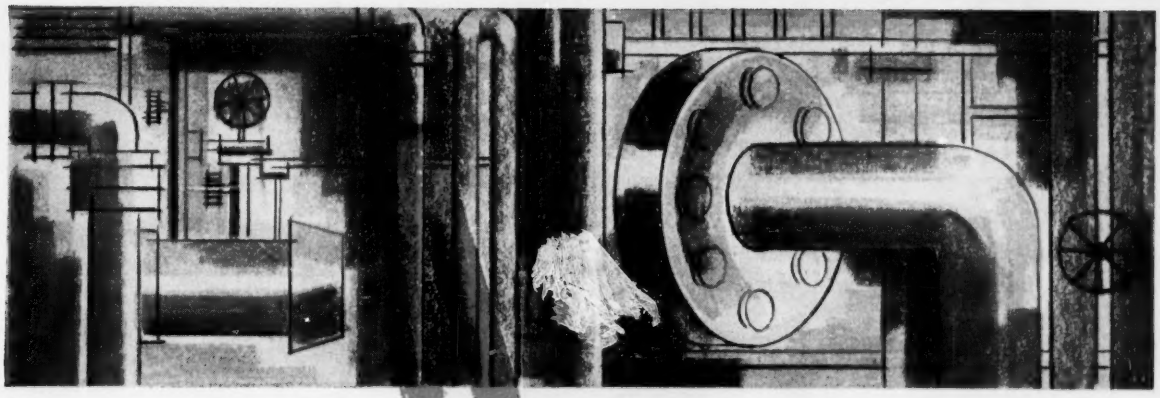
Radiation Dynamics, Inc., Westbury, N. Y., announced last month successful operation of its first 1.5-mev., 15-kw. Dynamitron particle accelerator. This machine sells for $60,000 and is said to operate at a cost of $0.50/kwh. RDI is now designing a new machine capable of 30 kw. output.

Meanwhile, *CE* has learned that High Voltage Engineering Co., Burlington, Mass., is developing a new accelerator to compete with the Dynamitron in both size and cost. Hivec's present line of Van de Graaff and microwave linear accelerators covers the range 2.5-6 kw.

Already on the market with a 26-kw. machine is General Electric. GE's cost figures, however, are two to three times those claimed by RDI and High Voltage.

The new accelerators differ in operating principles from older machines. The Dynamitron (U. S. 2,875,394) utilizes a cascaded rectifier system.

For more on DEVELOPMENTS.....46



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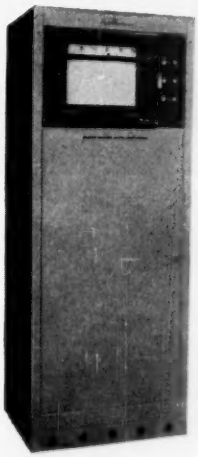
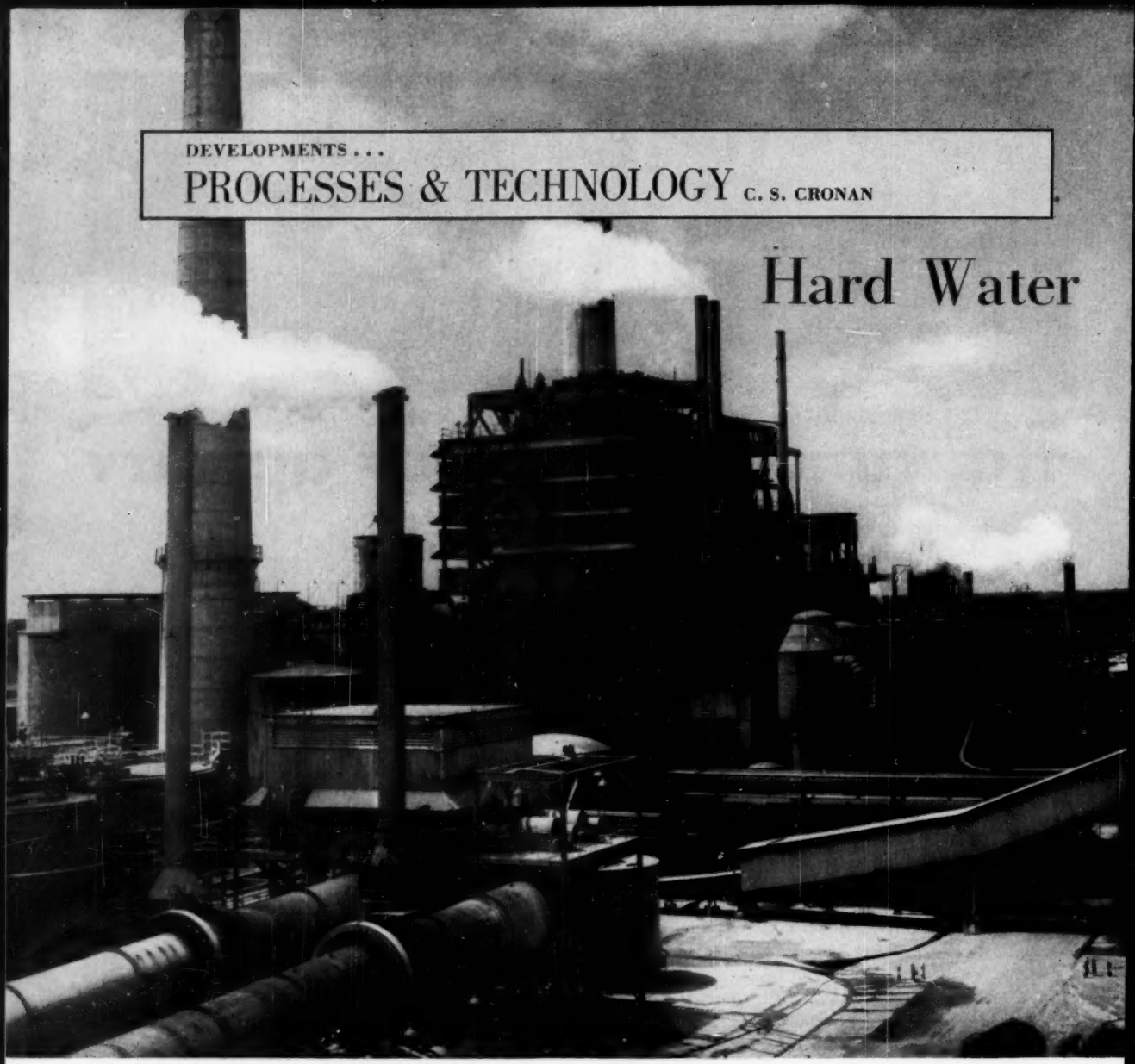


DEVELOPMENTS . . .

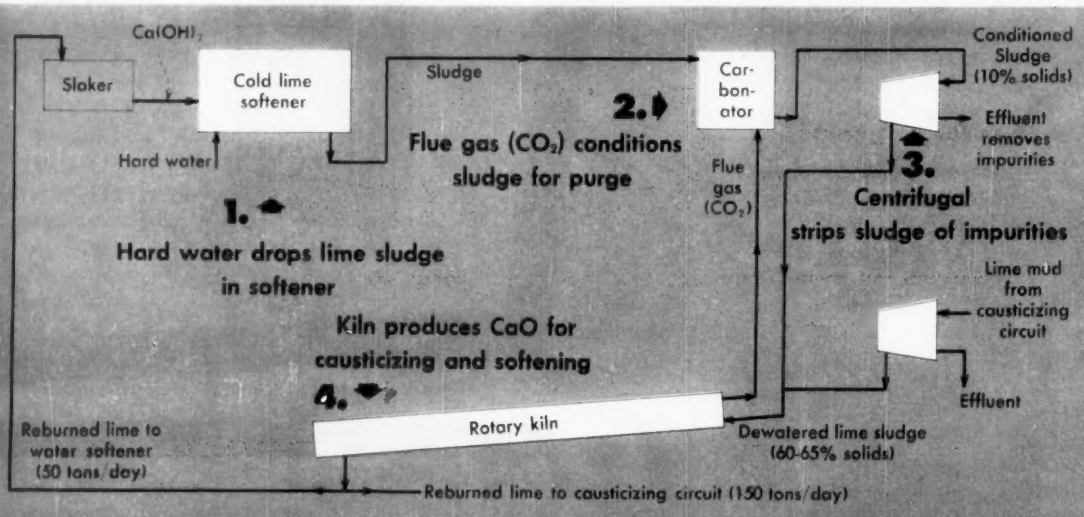
PROCESSES & TECHNOLOGY

C. S. CRONAN

Hard Water



PURGE of impurities in lime sludge by centrifugals feeding kiln gives Buckeye a new source of makeup lime.



Supplies Process Lime Needs

Novel system enables Buckeye Cellulose to convert water-softener lime sludge into feed lime suitable for causticizing circuit and water treating.

Onto the standard alkaline-pulping lime cycle, Buckeye Cellulose Corp. has grafted a unique source of makeup lime. Development is part of $20-million expansion at Foley, Fla., where Buckeye makes both kraft and high-grade dissolving pulps.

Rather than purchase some 50 tons/day of lime needed by its water softeners and pulp-liquor causticizing circuit, Buckeye converts sludge produced in its water softeners to usable chemical lime.

First, Buckeye purifies the sludge by centrifugal classification. Then it calcines the purged sludge together with washed lime mud from the pulp-mill causticizing circuit. Kiln discharges lime sufficiently pure and active for use in water softening process and to make up losses in the causticizing circuit.

▶ **Saves Many Dollars**—By calcining the sludge in the same kiln with the causticizing mud, Buckeye has realized major capital savings for its softening-sludge recovery. Also, the mill:

- Completely fulfills its lime needs by utilizing the lime content of its intake water, saving up to $5,000/mo.
- Eventually expects to gross $1,000/mo. from sales of surplus lime.
- Neatly eliminates discharge of waste lime sludge to lagoon.

▶ **First Process Use**—To attain this enviable position, Buckeye pioneered process-industry use of a lime recovery system already used by several municipalities and industries outside the process field.*

Success of recovery process hinges on sludge refining step which removes some of the magnesium, iron and aluminum compounds prior to calcining. And Buckeye has proved that this feature produces satisfactory lime for its operations.

▶ **Forms Mixed Sludge**—When Buckeye softens its supply of hard water by the cold-lime process, major constituents of the sludge form as follows:

$$Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2\,CaCO_3 + 2\,H_2O$$

$$Mg(HCO_3)_2 + 2\,Ca(OH)_2 \longrightarrow 2\,CaCO_3 + Mg(OH)_2 + 2\,H_2O$$

Note that each molecule of hydrated lime reacts with soluble bicarbonate to form two molecules of calcium carbonate. So, for each mole dosage of lime, the cold-lime process returns two moles of lime sludge.

In addition note that reaction with magnesium bicarbonate also forms a mole of magnesium hydroxide. At Foley, this reaction contributes 3-6% $Mg(OH)_2$ content to the sludge solids.

▶ **Needs Purge**—Before Buckeye can use this sludge as a source of fresh lime, purging is needed to reduce the proportion of $Mg(OH)_2$. Otherwise, each successive re-use of recovered lime would increase the magnesium level in the lime as additional magnesium precipitates from water being softened.

Without purging, magnesium soon would reach a level where it could cause trouble throughout the water treating and causticizing processes. And, it might even contaminate the pulp.

Operating at full capacity, Foley's intake of water from its deep wells flows at about 52 million gal./day. In the cold-lime softeners, total hardness of this water is reduced from more than 200 ppm. to 80 ppm., producing 100 tons/day of sludge. About 30% of the water gets further treatment in anion, cation and sodium zeolite exchangers to reduce hardness to less than 2 ppm.

▶ **Gets Purge**—From the softeners, sludge at 7-10% solids content is pumped to a tank and agitated while undergoing carbonation from a stream of kiln flue gas. The carbonation is believed to dissolve some of the magnesium compounds and convert unreacted hydrated lime to faster-settling calcium carbonate.

Carbonated sludge flows at 250-gpm. rate to a continuous solid-bowl centrifugal which carries out the vital purging of unwanted magnesium from the sludge.

Operating variables are controlled to settle out the heavier calcium carbonate as centrifuged cake while leaving the lighter magnesium compounds in suspension to discharge with the effluent.

Only enough magnesium need be removed to keep it from exceeding an acceptable level in the lime. With the system in balance this amount need only equal or

* Cities of Dayton, Ohio; Marshalltown, Iowa; and Miami, Fla. Plants operated by Wright Aeronautical Corp. and Columbia Steel Corp.

exceed slightly the weight of magnesium precipitated from the intake water.

Buckeye operates its centrifugal to purge about 60% of the magnesium and 60% of the iron from the sludge. At this level, recovery of lime averages about 80% (lime recovery varies inversely with magnesium removal).

▶ **Common Ending**—Solids from the centrifugal, containing about 35% moisture, fall onto conveyor feeding rotary kiln. Same conveyor also carries solids from adjacent identical centrifugal which is dewatering washed lime mud from causticizing circuit. A second kiln handles lime mud only.

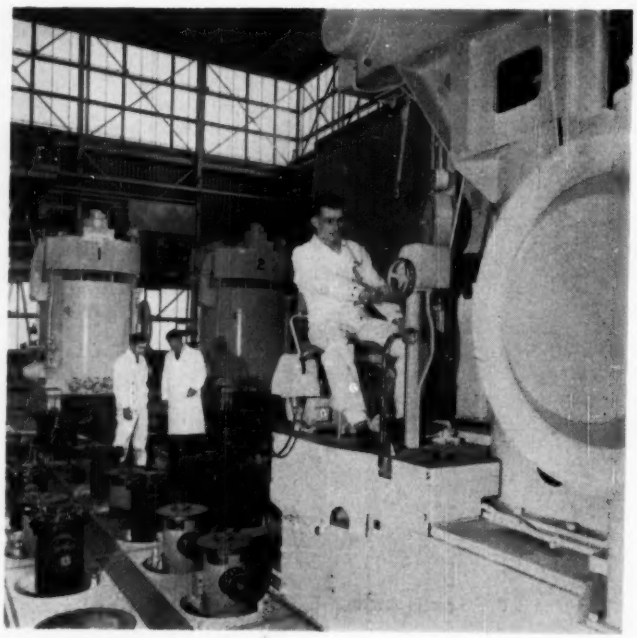
After cooling, the reburned lime goes to storage which supplies both the cold-lime softeners and the pulp-mill causticizing circuit.

Water Desalting: One for The Money; Two for Show

One $11-million commercial plant at Aruba Neth. W. I.; two 1-million-gal./day demonstration plants, one to be located on the Gulf Coast, the other on the West Coast: These latest events mark the most recent progress in saline water conversion.

General location of the two U. S. Government demonstration plants was confirmed late last month by Secretary of Interior Fred A. Seaton. First plant will be built at a site, yet to be chosen, on the Gulf Coast. Second plant, using nuclear reactor to furnish energy, will be built on a West Coast site.

Commercial plant in Aruba, completed last month by Singmaster & Breyer, has rated capacity of 2.7 million gal./day of fresh water and 15,000 kw. of electric power. Aruba plant uses a six-effect submerged-coil distillation process, is keyed to high efficiency by a special process based on ferric chloride treatment of sea water to keep calcium and magnesium soluble.



New Unit Recovers Chemicals From Sulfite Liquor

Recently opened by the Lord Lieutenant of Dumfriesshire, Scotland's first nuclear power station at Chapelcross will have a generating capacity of 184,000 kw. early next year when all four reactors are operating. Reactors are identical to those at Calder Hall, England (*Chem. Eng.*, Dec. 1956, pp. 114-116). Chapelcross, like Calder Hall, is intended primarily to produce plutonium. Photo shows charge and discharge machines for loading fuel elements of No. 1 reactor.

AIChE Pushes Exchange Of Computer Programs

At the recent Kansas City, Mo., meeting of the American Institute of Chemical Engineers (AIChE), computer program exchange got an encouraging push from the AIChE Council. Council approved both the budget and the areas of interest to be covered by abstracts or manuals published under auspices of Machine Computation Committee. Budget for 100 abstracts in 1959 and 1960, five manuals for 1959 and 25 manuals for 1960 envisages a $9,000 deficit for 1959 and a $49,000 profit in 1960 (figuring a sales cost of $30 per manual).

Staffed with top computer men,* computation subcommittees will prepare abstracts and manuals for chemical engineering calculations for design or engineering analysis, applied mathematics, analog techniques in dynamic analyses and related fields.

* W. M. Carlson, Du Pont; J. W. Kellett, Esso Research & Engineering; N. R. Amundson, University of Minn.; S. W. Churchill, University of Mich.; Leon Cooper, Monsanto; A. W. Hawkins, Du Pont; R. R. Hughes, Shell Development; E. R. Kent, Socony, Mobil; B. G. Price, Celanese; F. D. Parker, Arthur G. McKee & Co.; G. E. Jones, Koppers; H. D. Eddy, Standard Oil (Calif.); W. M. Harp, Humble; F. A. Landee, Dow; E. L. Meadows, Union Carbide Olefins; R. F. Sweeny, Applied Science Labs.

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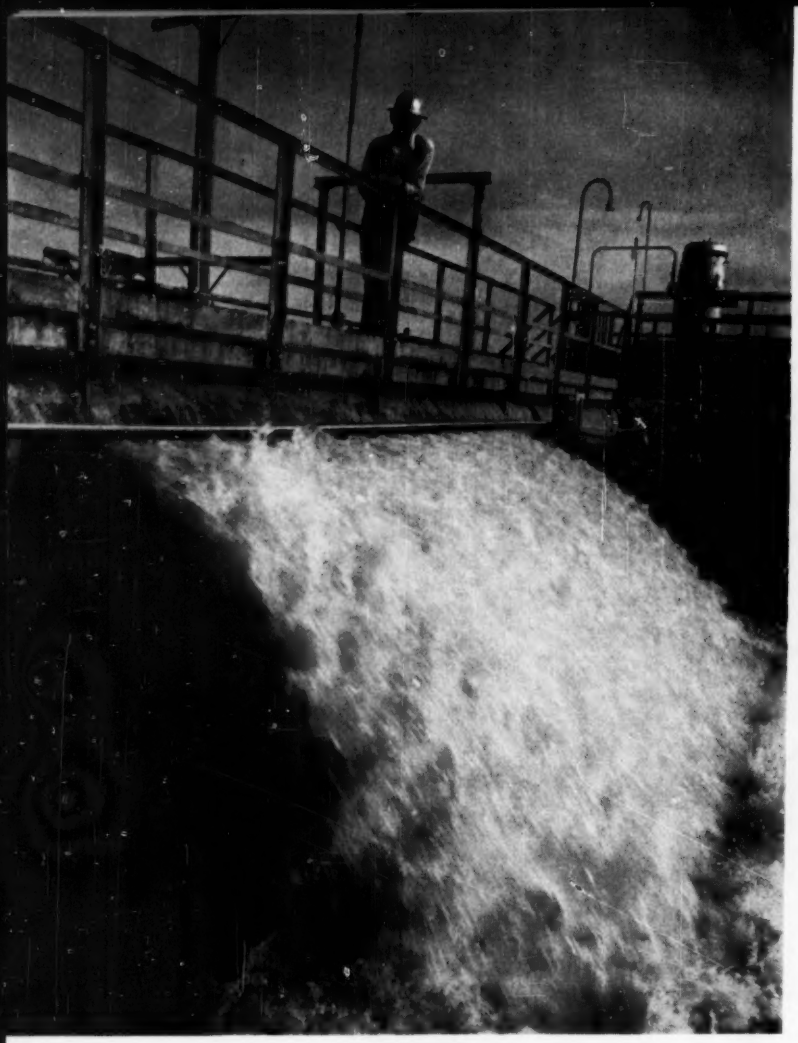
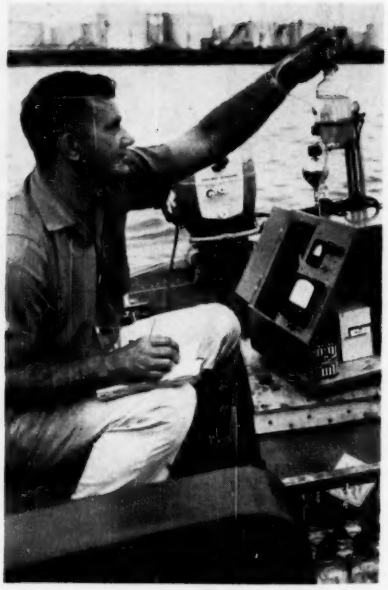




PORTABLE polarograph measures dissolved oxygen in channel water as check on reoxygenated effluent (left).

Planning Saves Waste-Disposal Dollars

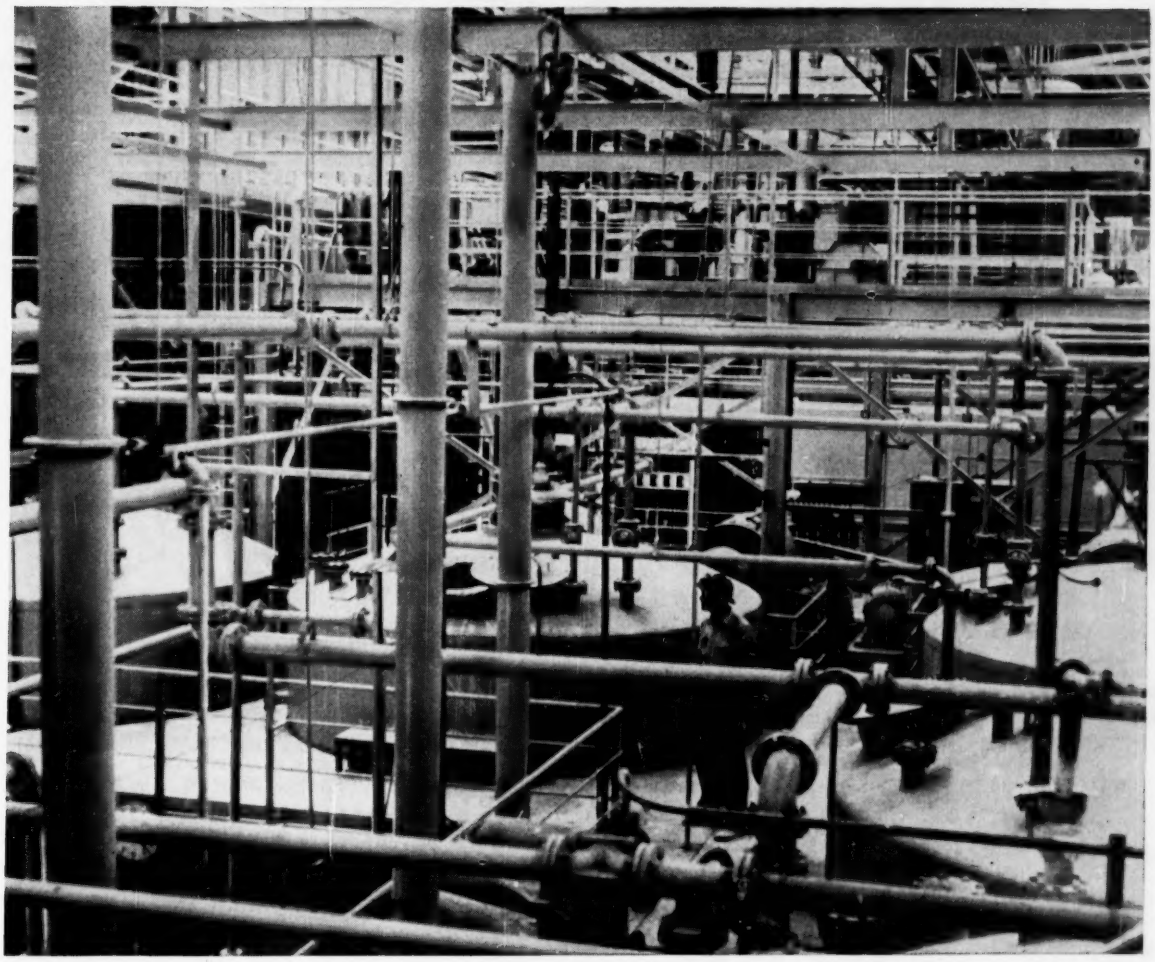
Now one company reveals the long-range plan used to schedule its waste disposal projects and to make sure it gets the most from expenditures.

Looking back over a program that spans nearly ten years, engineers at Humble Oil & Refining's Baytown, Tex., refinery happily view the rewards of their long-range pollution-abatement plan. Long-range planning, says Humble, is the key to effective pollution-control spending and a big help in dovetailing abatement projects with refinery modernization.

▶ **Catch Up On Pollution**—During the war years, Humble, with its refinery situated on the Houston ship channel, built refining units on a crash basis and had little time to consider waste-disposal problems, omitting items that might normally be included. Then as new industry moved into the area and new plants started up, pollution of the bays and streams became serious.

Humble's refinery is the last major industry on the ship channel before it empties into Galveston Bay. Therefore, management felt an added responsibility to make sure that refinery effluent

DOW | **SARAN LINED PIPE**



Saran Lined Pipe . . .
process lifeline with a hot acid cargo

When a complex piping system carries corrosive process liquors . . . when it must withstand constant thermal stress imposed by its high-temperature cargo . . . corrosion resistance and high physical strength are the keys to pipeline dependability.

The maze above is of Saran Lined Pipe, and is a part of the process piping at American Cyanamid's Savannah plant, Savannah, Georgia. Most of this pipe carries process liquors with a sulfuric acid content of 25% . . . at temperatures of 165° F. and above. Pumping pressures range upward to a maximum of 70 psig.

The chemical activity and high temperatures of the pipe's contents are severe threats to pipeline durability, but thanks to the extreme corrosion resistance and high strength of Saran Lined Pipe it has performed dependably for American Cyanamid since installation four years ago.

Similar sections of Saran Lined Pipe carry hydrochloric acid in concentrations as high as 37%, while others are used to transfer 10% caustic soda. In many areas other types of corrosion resistant piping have been replaced with new Saran Lined Pipe, with highly satisfactory results.

When processing systems require piping that must resist corrosion and chemical activity, under a wide variety of conditions, consider dependable Saran Lined Pipe. Saran Lined Pipe, fittings, valves and pumps are available for systems operating from vacuum to 300 psi, from below zero to 200° F. They can be cut, fitted and modified easily in the field without special equipment. For more information, write Saran Lined Pipe Company, 2415 Burdette Avenue, Ferndale, Michigan, Department 2280AK6-29.

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

BACTERIA and algae in experimental oxidation pond consume organic matter in refinery effluent.

wasn't detrimental to marine life. Moreover, Humble recognized that many pollution problems had to be solved before it could begin any extensive modernization.

Systematically, Humble attacked the problem this way:

- Established physical and chemical inspections of effluent in order to define and measure its quality.
- Made a comprehensive survey of its major refinery streams.
- Refined its pollution evaluation yardsticks after completing the first few projects.

▶ **Measure**—Humble's measurements of effluent quality or "characteristics" were used throughout the program. In addition, the refinery also estimated the relative importance of each characteristic and set an improvement goal, thus fixing its "improvement factor." (See table).

▶ **Take Action**—Data collected on the comprehensive survey were tabulated on large sheets (horse blankets) to show how each refining unit contributed to over-all pollution.

Engineers also estimated the effect of each waste-disposal project on over-all pollution and how much it would cost. Thus Humble was able to compare effluent projects consistently with each other and with profit-making modernization.

Sample estimates for two out

Improvement Project Estimates Were Based on Measurement of Effluent Characteristics

Quality Characteristics	Problem Analysis				Typical Projects			
	Start of Program	Goal	% of Total Problem[1]	Improvement Factor[2] (%/Unit)	Reduce Salt Water Cooling †	Reduce Salt Water Cooling *	Bay Pump Over †	Bay Pump Over *
Temperature (deg. F.)	125	100	10	0.4000	11	4.4	7	2.8
Oil content (ppm.)	700	77	15	0.0240	10	0.2	37	0.9
Dissolved oxygen (ppm.)	−6.0	5.0	20	1.8200			4.2	7.7
pH	3.0–11.0	5.5–8.5	15	6.0000			1.0	6.0
Turbidity (ppm.)	500	100	5	0.0125			120	1.4
Chemical oxygen demand (ppm.)	200	40	5	0.0909			15	1.4
Suspended solids (ppm.)	190	50	5	0.0938	10	0.4	40	1.4
Sulfides (ppm.)	20	1	10	0.5260	−6	−3.0	9	4.7
Biochem. oxygen demand (ppm.)	200	40	15	0.0938	24	2.2	35	3.3
Percent contribution to solving total problem						**3.2**		**29.6**
Cost ratio, $/% contributed						**102,000**		**1,700**

[1] Assigned on basis of best guess of relative effect on marine life. [2] Improvement factor is determined thus: Temperature, for example, is valued at 10% of the total problem; the goal is a change of 25 deg. F. Each degree of change, therefore, results in a percent improvement of 10/25, or 0.40. † Improvement expressed in units of that particular characteristic. * How much project improves a characteristic; improvement is expressed as percent project contributes to improvement of that characteristic in total refinery effluent.

LAPP ALL-SERVICE ACID PROOF VALVES

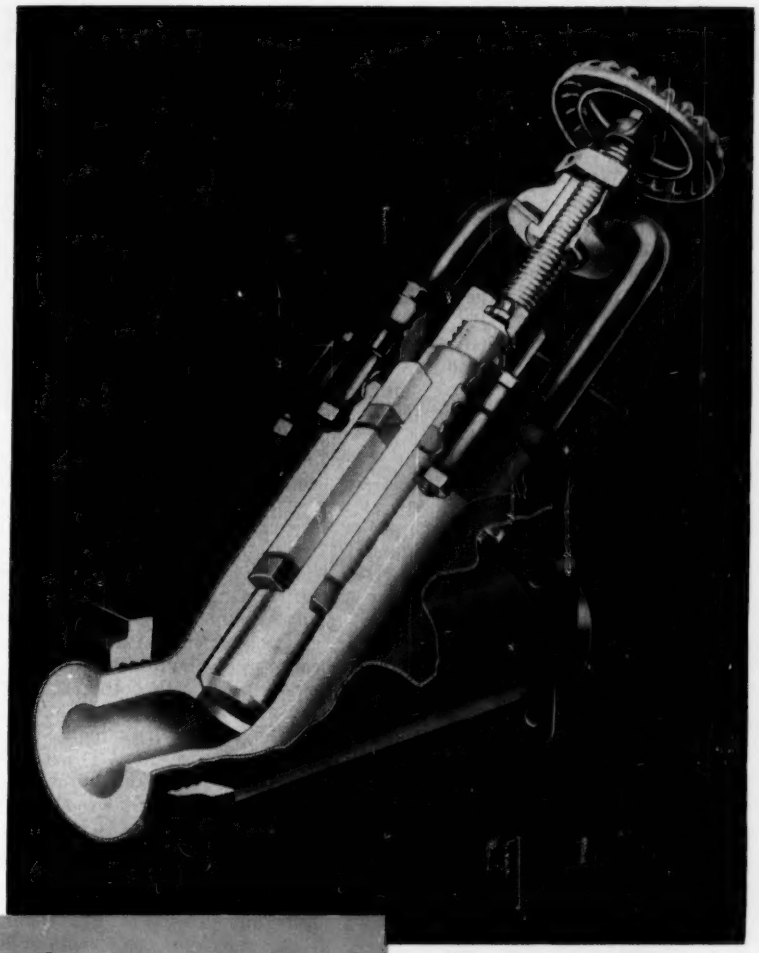
SOLID CHEMICAL PORCELAIN WITH **LAPP TUFCLAD®** ARMOR

Nothing defies corrosion like chemically inert porcelain. As made by Lapp, it is pure, dense, hard, close-grained, homogeneous and non-porous. Therefore there can be *no penetration—no crumbling* from capillary pressures—*no absorption* of liquids to contaminate later processing.

Resistance to corrosion and contamination is but part of the Lapp story; there's a *bonus* in that Lapp Chemical Porcelain costs considerably less initially than most corrosion-resistant alloys and lined equipment. *And* since it almost never needs maintenance or replacement, the economy of your purchase is further increased.

Security (protection of plant and personnel) is assured by the Lapp TUFCLAD armor. It consists of multiple layers of fiberglass impregnated and bonded to the porcelain with an Epoxy resin. Fiberglass has high strength and chemical resistance providing protection against impact damage and external thermal shock. TUFCLAD armor holds line pressures even should porcelain become cracked or broken.

***WRITE** for description and specifications for the entire line of Lapp Acid Proof Valves. Lapp Insulator Co., Inc., Process Equipment Div., 2206 Chestnut Street, LeRoy, N. Y.*



Lapp CHEMICAL PORCELAIN

Y-Valves as shown, and Angle Valves are available in Lapp TUFCLAD Chemical Porcelain in ½" to 6" sizes. Also safety valves, flush valves, plug cocks, pipe and fittings (to 8" dia.) and special shapes.

of a total of 25 projects are shown in table.

▶ **Review** — After spending about $3.5 million out of an estimated $5 million total, Humble compared actual benefits with those predicted. Some discrepencies cropped up because the program was not followed rigorously and process modernizations differed from predictions.

Too, Humble found that the grading system could become more sensitive when allowing additional credit for bettering the quality goals.

▶ **Benefits of Method**—One of the more important uses of this grading system, Humble points out, is in the design of new process equipment. The company considered design of units incomplete until adequate effluent facilities were ensured.

Engineers evaluated each potential waste stream in the process design stage. Its effect on refinery effluent quality dictated routing it to the most suitable treating units for that type of waste.

In deciding whether a waste stream should be treated by new facilities or by existing ones, the grading system was used to estimate monetary credits or debits.

For example, Humble estimates that its investment in treating facilities for lowering biochemical oxygen demand (BOD) averages about $25/(day)/(lb.). If process design on a unit indicates that a stream will contribute heavily to BOD, it's a simple matter to evaluate this contribution at $25/lb. and install the cheapest facilities to lower BOD to an acceptable level.

Grading system has also been useful in showing the upward trend of refinery effluent quality since the beginning of the program. Humble has charted the arbitrary average of all nine qualities in the grading system and, in important cases, has charted individual qualities.

▶ **Some Shortcomings**—While pleased with its long-range system, Humble recognizes some shortcomings.

System doesn't give the best indication of the percent time that a quality is actually within the goal. This would require more tabulations and calculating; Humble has no plans to recalculate data at this time.

Too, system doesn't account for items known to contribute to toxicity of over-all pollution. These items, which include toxic materials, are now evaluated separately. But they could be included in the system without much trouble.

Acid-Gas Removal Process Crosses Atlantic to U. S.

Giammarco-Vetrocoke process for removing acid gases from synthesis or natural gas is now available in U. S. through Fluor Corp. and other engineering and construction companies. Process is operating in several European countries, and already at least one U. S. plant is under construction to remove CO_2 and H_2S from high-pressure natural gas.

G-V route can remove CO_2 and H_2S separately or in the same plant. Sodium and potassium carbonate solutions containing tri- and pentavalent arsenic are used to remove H_2S and, under proper conditions, can be selective for H_2S in the presence of CO_2. Typical inorganic additives for CO_2 removal are arsenic oxide, selenious and tellurous acids. Additives sharply increase rate of absorption and desorption of CO_2.

New process claims better performance over conventional monoethanolamine (MEA) or carbonate removal processes because of amine losses in the former case and, in both cases, because activated solution can be regenerated with much less steam consumption. (Too, in G-V process, air can be used to regenerate instead of steam.) Another advantage is noncorrosive nature of G-V treating solution.

In comparing economics of different processes, Fluor considers a natural gas stream of 90 million cfd. at 1,000 psig. and 100 F. containing 28% by volume of CO_2 and 2 grains/100 scf. of H_2S. Treating costs (per Mscf. of gas treated) are: for G-V—4.1¢ (with air regeneration), 4.8¢ (with steam regeneration); potassium carbonate — 8.2¢; aqueous MEA—10.1¢.

NEWS BRIEFS

Cryogenic fluids: Linde Co. has now advanced the date for startup of its liquid hydrogen plant at Torrance, Calif. Plant, with capacity "in excess" of 10,000 lb./day liquid hydrogen (95% para-hydrogen), is now scheduled for completion in about one year. Raw material is to be impure hydrogen from Union Carbide Olefins' facility at Torrance. Linde's 300-ton/day liquid oxygen and nitrogen plant at Pittsburg, Calif., came on stream last month, nearly a month ahead of schedule.

Spliceless hose: Goodyear Tire & Rubber Co. has developed a new process to build large-diameter hose without splices. First project was 4-in.-dia. hose produced in 500-ft. lengths to transport military fuels. New process is a closely guarded secret; but it's known that hose liner is wrapped and sealed on a mandrel wrapped with reinforcing cord, bagged and cured in a continuous cycle.

In-pile test loop: Lummus Co. Engineering Development Center at Newark, N. J., recently completed assembly, test operation and dismantling of a ¾-in.-dia. in-pile test loop for Westinghouse Electric Corp. Loop was built for experiments with irradiation of fuel-element and control-rod designs for reactor to be installed by Yankee Atomic Electric Co. at Rowe, Mass.

Solid propellant: Chromalloy has developed a new solid composite propellant with "significantly improved" properties over previously known composite propellants. Chief advantage is a lower "temperature coefficient" which reduces variation in performance.

Thin aluminum: Soviet news Agency Tass reports that a new 20-roller facility at aluminum plant at Starokramatorsk, Ukraine, will produce aluminum sheets of uniform 3-micron thickness. Thickness will be checked and controlled by use of radioisotopes.

process

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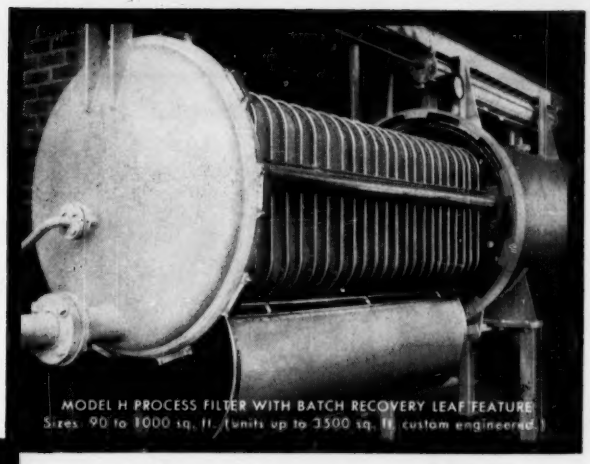
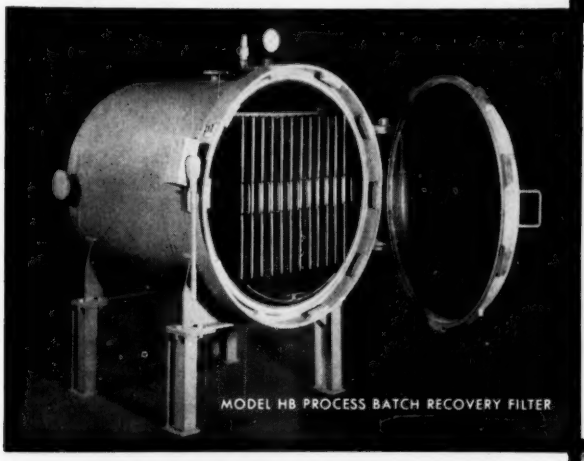


MODEL H PROCESS FILTER WITH BATCH RECOVERY LEAF FEATURE
Sizes 90 to 1000 sq. ft. (units up to 3500 sq. ft. custom engineered.)



MODEL HB PROCESS BATCH RECOVERY FILTER

...example

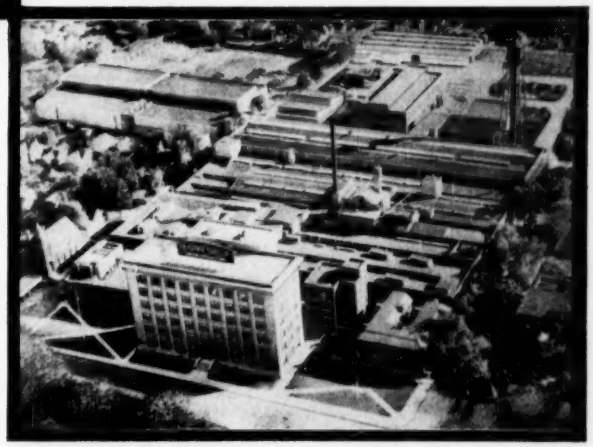
batch filter

A 40 sq. ft. Process Model HB Filter clocked 1¾ hrs. in filtering a 2500 gallon batch—actually doing the job in less time than a 160 sq. ft. plate and frame filter. Residue remaining in the tank at the end of the regular filtration cycle was blown through the recovery leaf in five minutes.

Cake discharge took 8 minutes.

dependability counts

PROCESS FILTERS DIVISION laboratory and plant are now part of the original Bowser, Inc. facilities pictured at right. You can rely on PROCESS FILTERS' product and service!



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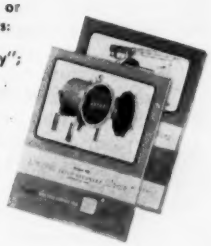

PROCESS FILTERS

MARKETING DIV., BOWSER, INC.
FORT WAYNE, INDIANA

Who's Who Among the Free World's Chemical Giants

	Million Dollars					
	Total Sales		Export Sales		Capital Spending	
	1957	1958	1957	1958	1957	1958
Du Pont (U. S.)	1,964	1,825	163	161	220	231
Imperial Chemical Industries (Gr. Br.)	1,300	1,300	215	207	142	126
Union Carbide (U. S.)	1,395	1,296	98	91	191	144
Farbenfabriken Bayer (W. Ger.)	441	479	183	200	107	70
Badische Anilin & Soda Fabrik (W. Ger.)	430	460	161	170	54	60
Farbwerke Hoechst (W. Ger.)	421	450	136	140	N.A.	57
Montecatini (Italy)	244	235	70	59*	21	36
Rohm & Haas (U. S.)	174	177	21	22*	35	13
Canadian Industries (Canada)	143	141	N.A.	N.A.	16	12
Chemische Werke Huels (W. Ger.)	125	137	44	48	16	18
Sumitomo Chemical (Japan)	80	84	12	12	20	12
Du Pont of Canada (Canada)	73	82	N.A.	N.A.	15	11
Mitsubishi Chemical Industries (Japan)	50	57	N.A.	N.A.	35	17
Toyo Koatsu (Japan)	54	57	19	17	2	2

* *Chem. Eng.* estimate; N.A., not available

Foreign Firms Cut U.S. Chemical Lead

Lifted from war's prostration by such great names as Bayer, ICI and Montecatini, overseas chemical industry bids for world markets.

Richard P. Windisch, W. E. Burnet & Co., New York, N. Y.

During World War II, chemical production in the United States shot ahead of that in most other countries because of its vital role in conducting the war, and because this country had an abundant supply of low cost capital and raw materials with which to exploit new products and processes as fast as they were discovered.

At the same time many foreign nations competing in the export field were handicapped by heavy war destruction and lack of capital and materials.

▶ **The Party's Over**—These advantages, only temporary at best, have been largely dissipated. Figures published late last year show that total chemical production in the 16 nations of OEEC (Organization for European Economic Cooperation) increased 10% in 1957 vs. 3.5% in the U.S. Add to this an increase of 6% in the first half of 1958 compared to a decline of 9.2% in U.S. chemical output.

Many foreign chemical companies are now in a better position to meet the heavy capital demands of the industry, and are in an active period of growth. Through affiliations—

WILLIAMS ROLLER MILLS

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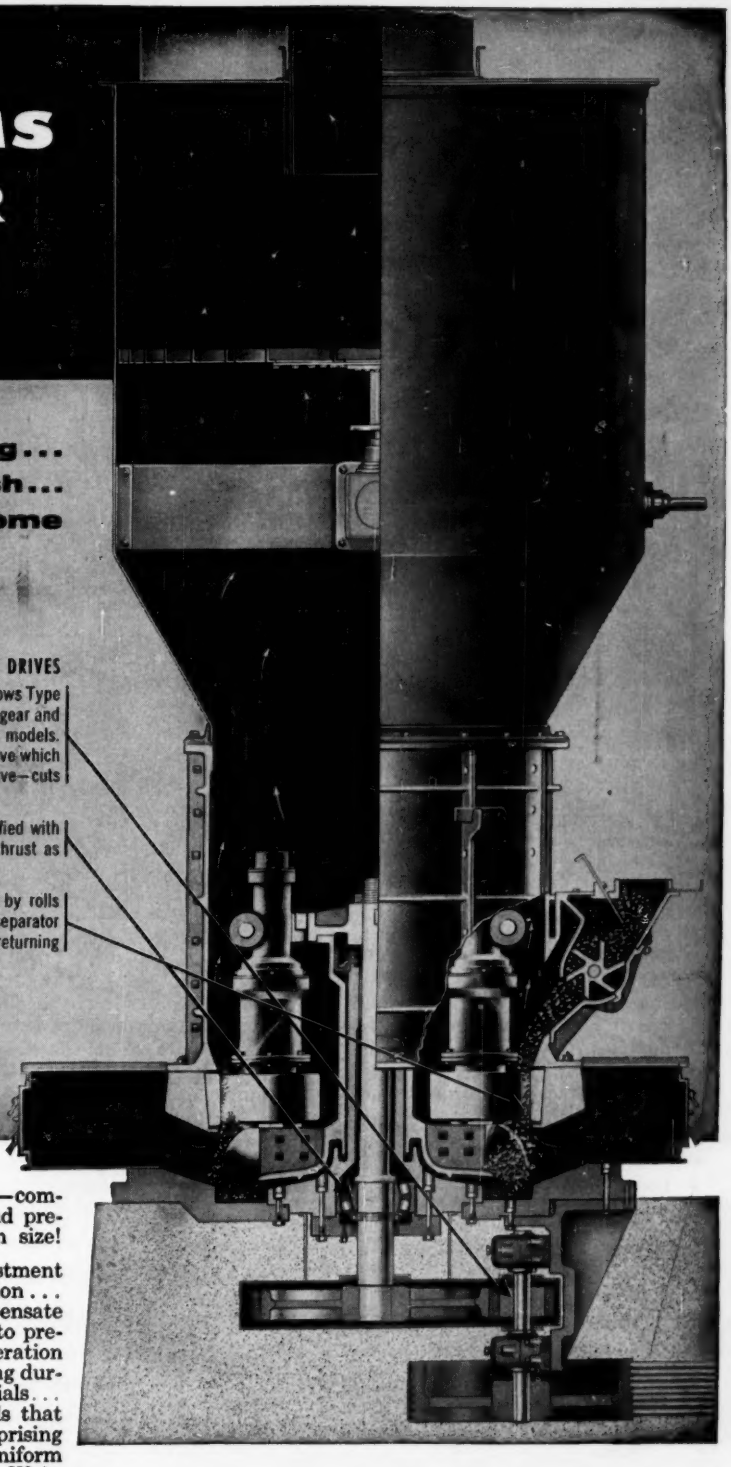

EXCLUSIVE GEARLESS AND SPUR GEAR DRIVES

Another Williams advancement! Cutaway shows Type D Mill with Spinner Air Separator with spur gear and pinion drive used on Standard and larger models. Smaller sizes have simple gearless V-belt drive which is easier to maintain than bevel gear drive—cuts labor and downtime.

Bearing alignment of central shaft is simplified with only 2 bearings, the bottom one carrying thrust as well as radical load.

NOTE FLOW OF MATERIAL being ground by rolls rotating against bull ring, then air-swept to separator which discharges finished product while returning coarse tailings for regrinding.

From raw material to finished product—completely automatic grinding, blending and precision classifying to 20 mesh or micron size!

Self-adjusting feed rate . . . instant adjustment for sizing, even while mill is in motion . . . continuous automatic take-up to compensate for wear . . . constant rising air current to prevent build-up of fines and inefficient operation . . . automatically controlled hot-air drying during grinding of moisture-carrying materials . . . all are features of Williams Roller Mills that virtually guarantee increased output, surprising cost reductions and exceptionally high uniform quality. Get all the facts immediately . . . *Write today for catalog.*

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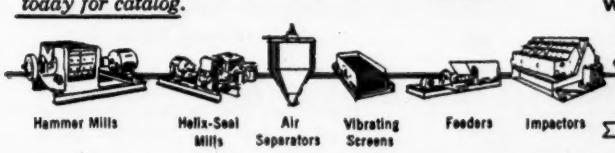


WILLIAMS

CRUSHERS GRINDERS SHREDDERS

Oldest and Largest Manufacturers of Hammer Mills in the World

and the willingness of companies to sell and license their know-how abroad—certain overseas chemical companies are in a position to profit from the great technical progress which was so expensively developed in the U. S. through the heavy research and development outlays of the last two decades.

Great Britain

ICI, No. 2 in world chemicals, accounts for one-third of the U.K.'s share.

The chemical industry is the frontrunner among major British industries for modernity of plant. Nearly $2 billion was invested between 1948 and 1957. The petrochemicals segment, Europe's biggest, has laid out $196 million since the war, will spend almost as much in 1958-60 (see table, this page).

Since 1948, chemical output has doubled (vs. a 40% increase for all British industry). Plastics output has trebled. Pharmaceutical production has doubled.

▶ **Four Into One**—In 1926, four great British chemical companies, each dominant in its particular field, were consolidated into one gigantic unit known as Imperial Chemical Industries, Ltd. These companies were British Dyestuffs, United Alkali, Brunner Mond (soda ash, ammonia) and Nobel Industries (explosives, cellulose).

This combination — far broader in scope than anything in this country at that time—became a trust with government blessing. It was similar to those evolving contemporaneously in Germany, Italy, France, Belgium and Czechoslovakia.

Today ICI operates over 100 works in the United Kingdom, makes 12,000 different products and employs 116,000. It is reputed to be the largest manufacturing corporation in England and accounts for one-third of Britain's chemical sales.

▶ **Global Interests**—ICI is also one of Britain's largest exporters and sells just over a quarter of its production overseas in 42 countries. Besides having large subsidiaries in Australia, Canada and South Africa, it also manufactures in Argentina, Austria, Brazil, Chile, France, Germany, India, Ireland, Kenya, New Zealand, Pakistan, Spain and the U. S.

With sales of $1.3 billion (almost all chemically processed), ICI probably ranks next to Du Pont as the second largest chemical producer in the world.

ICI has been a pioneer in developing polyethylene, polyester fibers and several well-known pesticides such as 2,4-D and benzene hexachloride. Since 1946 it has built a large petrochemical plant near Billingham on the River Tees, and has just announced a major new petrochemical complex on the River Severn which will cost $280 million over ten years.

ICI is prominent in the production of plastics, paints and fertilizers. It also has a strong interest in new metals, like beryllium, and organosilicon compounds. Recently, ICI's efforts have been turned to pharmaceuticals and photographic products (Ilford), which so far have not been prominent in its growth.

ICI has a high-purity silicon plant operating now, an acrylotrile plant under way (Britain's first) and a polypropylene plant in the planning stage.

▶ **Whiskey and Chemicals**—Another prominent factor in Britain's chemical business is Distillers, Ltd. (world famous for producing two-thirds of England's whiskey and gin). In the last two decades Distillers has become the producer of 90% of England's calcium carbide, a large portion of her organic solvents, antibiotics, plastics—and sole producer of magnesium metal.

Distillers has a strong position in petrochemicals, through subsidiaries, and has a tieup, through working agreements and subsidiaries, with Monsanto, Oronite (Standard of Calif.), Dow, Hercules Powder, Shawinigan, Commercial Solvents and Courtaulds. Together with Monsanto, Distillers is building a large chemical plant adjoining British Petroleum's new refinery.

▶ **Feedstock Flood**—Britain is already the world's second biggest petrochemical producer—and her opportunities are tremendous. As petroleum supplants coal as fuel, great quantities of low-cost refinery gas will become available.

Present refinery capacity for crude oil is about 600,000 bbl./day. A second major expansion, already under way, will bring this capacity up to over 900,000 bbl./day.

Esso and Shell have announced plans to build their own chemical plants adjoining their refineries.

Overseas Capital Spending: A Petrochemical Explosion

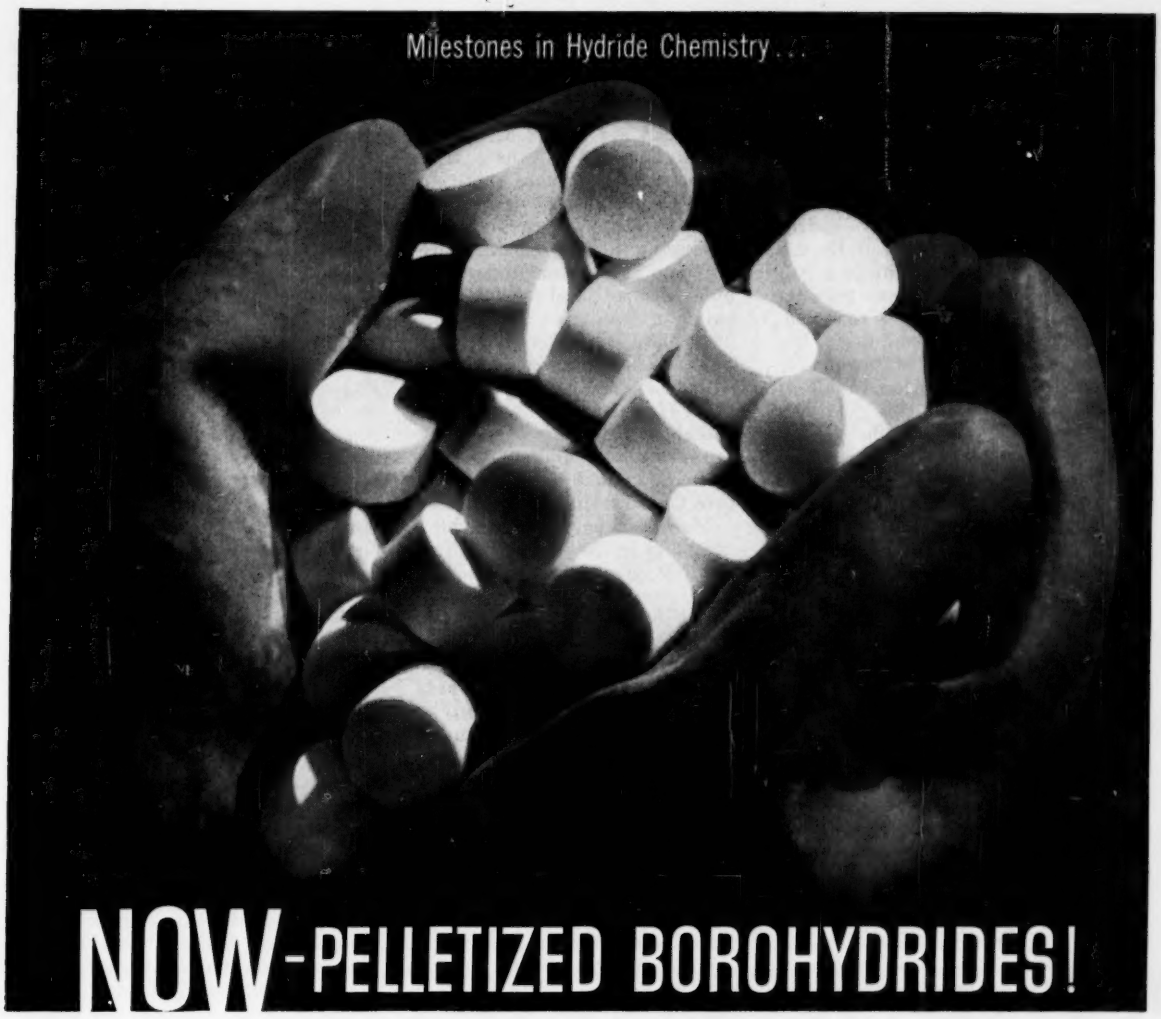
(Million Dollars)

	Through 1956	1957–59	Through 1959
Britain	170	144	**314**
France	50	240	**290**
West Germany	128	150	**278**
Japan	31	162	**193**
Italy	51	100	**151**
Holland	13	10	**23**
Belgium	6	17	**23**
Total	**449**	**823**	**1,272**

Italy

Montecatini: Synonym for Italian chemicals and world-famous technology.

Montecatini directly accounts for much of Italy's chemical production. (It figures in a



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Sizes of the new pellets are 10/32″ and 24/32″ in diameter. Bulk density averages five pounds to the gallon. The pellets are hard and resist crushing or dusting. Further information and technical service is yours without obligation. Write, wire, or phone today!

New, too! $NaBH_4$-SWS Write for complete details concerning MHI Sodium Borohydride SWS — the new stabilized water solution form that cuts the price of $NaBH_4$ more than in half!

CHEMICAL HYDRIDE DIVISION

Metal Hydrides Incorporated

PIONEERS IN HYDRIDE CHEMISTRY

629 CONGRESS STREET, BEVERLY, MASSACHUSETTS

even larger percentage through subsidiaries.) The company controls 174 plants and mines (56 outside Italy), and employs 60,000.

Montecatini's large hydroelectric plants, located in the Southern Alps, account for 8% of Italy's entire power production. Montecatini, it's reported, is, through its subsidiaries, the largest producer of power for internal consumption in all of Europe. Some of this power is used in its aluminum plants, nonferrous metal smelters and marble quarries.

This company's production also covers almost all branches of the chemical industry, from fertilizers to pharmaceuticals, including plastics, fibers, dyes, paints and explosives. Montecatini takes a leading role in Italy's oil exploration, produces one-half her aluminum and, with FIAT, will build Italy's first atomic energy plant.

At Brindisi, Montecatini is building a $90-million chemical complex to process 1 million tons/yr. of liquid hydrocarbons into a wide range of derivatives.

▶ **Far-Flung Know-How**—Montecatini is a leader in research and engineering (ten centers) with credit for developing processes for making fertilizers (urea) and plastics, for which it receives royalties from users around the world.

Montecatini's recent development of catalysts for controlling stereospecific polymerization of plastics has fundamental significance. Its ammonia process is also world famous, being used by 60 companies in 24 countries.

A new formaldehyde process has just been announced, and work on a new synthetic rubber called PEP is very promising. Montecatini's PEP is a polyethylene-polypropylene copolymer whose raw materials cost one-third as much as those for SBR rubber.

▶ **Watch Edison** — Although Montecatini is the synonym for Italian chemicals, another name may soon be added—Societa Edison, Italy's largest private concern, which in the last couple of years has become the country's second most important chemical complex.

Much of this growth is with American aid—from Monsanto, Union Carbide and now from Chemstrand. Edison and Carbide, going 50-50, have formed Societa Celene, which has begun producing high pressure polyethylene at Mantua under Carbide license and which will build an ethylene-oxide derivatives plant in 1960.

And Chemstrand has joined with Societa Edison and I. C. P. M. (Industrie Chimobe Porto Marghera, Europe's biggest hydrofluoric acid maker) to form Aosa, a company to manufacture Chemstrand's acrylic fiber.

Most important chemical company in the complex Edison holding group is Sicedison, a joint venture with Monsanto. Sicedison is in charge of a new Matua petrochemical facility, a vinyl and polystyrene plastics operation at Port Marghera, and a plant currently being set up at Priolo, Sicily, to make potash and phosphate fertilizers.

Italy's biggest drug firm, Societa Lepetit, just started up a $2-million pharmaceutical firm in Mexico City, said to be the largest in Central America.

Italy stands at the gateway of some of Europe's lowest cost petroleum sources and has a well-located natural gas production of its own. With its abundant water, labor supplies and good harbors, Italy is in an ideal position to develop a low-cost petrochemical industry.

West Germany

The Big Three—Badische, Bayer and Hoechst—still rule a complicated roost.

The German chemical industry presents a highly complex corporate picture. Affiliates, subsidiaries and associates are legion.

Here we also find the most highly developed and integrated production setup anywhere in Europe since there has been much less intercompany selling (only 20%) than in the U. S. This is fostered by a turnover tax from which other European countries also suffer.

▶ **From Coal to Oil**—German chemical industry has been based primarily on the nation's rich coal and saline deposits. However, West German postwar expansion — $4 billion since war's end to 1957—so far involves $190 million for new petrochemical plants, with $100 million more planned. (This is exclusive of the cost of converting old coal-based plants to a petroleum feed.)

West Germany's oil refining capacity of 300,000 bbl./day is to be expanded to 600,000 bbl./day by 1961 and probably a million bbl./day by 1965.

During the period between the two world wars, the major proportion of German chemical production wound up in the great I. G. Farben Industries. At the beginning of World War II, I. G. Farben was unquestionably the largest chemical company in the world, with sales estimated at $660 million—compared with Du Pont's $346 million in 1940.

▶ **Big Three**—One of the conditions of the peace treaty was that German cartels be abandoned and a state of free competition restored. The main portion of I. G. Farben's operations located in West Germany went to three successor companies known as Farbenfabriken Bayer, Farbwerke Hoechst and Badische Anilin & Soda Fabrik, and their affiliated companies and subsidiaries.

This triumvirate is estimated to own 36% of the former Farben assets. Another 36% was in the Soviet zone, and the balance was lost abroad.

Each of the Big Three is highly interested in dyestuffs and, due to the national scarcity of wood and metals, in plastics. However, each features different types.

Bayer also features photographic products (Agfa), pharmaceuticals and pigments. Hoechst has pharmaceuticals, industrial gases, phosphorus and fluorine chemicals, cyanamide, synthetic fibers and films. And BASF concentrates on calcium carbide, synthetic detergents and high pressure syntheses (ammonia, acetylene).

▶ **Joint Ventures**—Bayer has a joint subsidiary in the U. S. with Monsanto (Mobay), Badische with Dow, and Hoechst

Now you can predict service life because Byers PVC Pipe Engineering brings a factual approach to piping system design

FACT: Byers PVC Pipe performance data is available on corrosion resistance, allowable stress, temperature, pressure, impact, vibration, etc., etc.

A testing program of major proportions gives substance to Byers PVC Pipe performance data. The facilities, techniques and extrapolation brought into play assure our customers predictable service life.

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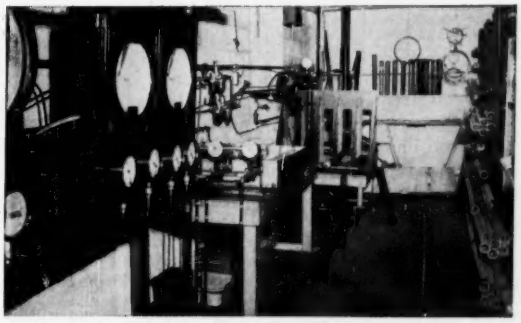
Since each manufacturer's PVC pipe has its own unique properties, compilation of test data is a must. An evaluation of our PVC pipe performance data will save you installation and maintenance dollars. Call a Byers field representative for details. A. M. Byers Company, Clark Building, Pittsburgh 22, Pennsylvania.



A section of the laboratory where Byers PVC Pipe runs the gamut of physical tests to determine long term pressure data. General Tire and Rubber Company's Bolta Products Division in Lawrence, Massachusetts is the site of the laboratory.

BYERS PVC PIPE

Write our Engineering Service Department for copy of this new 32-page illustrated catalog on Byers PVC Pipe.

with Hercules. In the six-year period since their segregation in 1953, aggregate sales of the Big Three have increased from $150 million to $1,288 million in 1957. Each company now sells about 11% of West Germany's chemicals.

Bayer and Hoechst are pushing plans for joint plant venture (Colour-Chem., Ltd) to manufacture pigments near Bombay. Badische is joining other German firms (Uhde and CITRA) to build final unit of the nitrogen fertilizer plant at Aswan, Egypt.

The Farben successors have ancestries going back to early coal-tar days; each was a sizable company at the turn of the century. Each also has a record of outstanding contributions to world chemistry, besides those in the dyestuffs field: Bayer, with aspirin, titanium dioxide, organic insecticides and isocyanates; Hoechst, with serums, vaccines and hormones; and Badische, with synthetic indigo, contact sulfuric acid, nitrogen fixation and acetylene chemicals.

▶ **Huels Is Hot**—While the Big Three—Badische, Hoechst and Bayer—have moved forward in solid, reliable fashion, fourth-ranking Chemische Werke Huels has been coming fast. It doubled sales from 1951 to 1957—$60 million to $125 million.

Between 1951 and 1957, Huels invested $87 million, three times its basic capital, to build two plants to produce detergent raw materials, a chlorinated hydrocarbon plant, an acrylonitrile plant, ethylene oxide plant and a unit for reprocessing waste sulfuric acid.

To cap it all off, Huels went 50-50 with the Big Three in establishing last year a marvel of synthetic-rubber-producing automation at Bunawerke Huels.

France

Close-mouthed, nationalistic, French chemical industry has many fine cooks.

France has 12 chemical companies, each of which manufactures over $25-million of chemicals a year. Outstanding among the firms are Rhone-Poulenc, Etablissements Kuhlmann, Saint Gobain and Pechiney.

The first of these, Rhone-Poulenc, has sales of over $100 million, largely in pharmaceuticals, cosmetics, fine organics, solvents and plastics. Kuhlmann, established in 1825, has ancient coal-tar ancestry and seems very alert in rotating its activities toward the new petrochemicals and their integration products, and is also a large producer of fertilizer and calcium carbide.

Pechiney's sales are almost half in aluminum. Besides being identified with the development of France's bauxite deposits, it will have a prominent position in colonial development along this line.

Pechiney is also France's leading electrochemical producer, particularly in chlorine, caustic and calcium carbide. Like other chlorine producers, it has ventured into plastics.

▶ **From Glass to Chemicals**—Saint Gobain (founded by Louis XIV in 1665 to break the Venetian glass monopoly) is still France's biggest name in glass. As early as 1806 the company began to make its own soda ash. This, in turn, led to sulfuric acid. As a result, the company has become one of the leading producers of plant foods, particularly phosphates and nitrogen.

Saint Gobain's interests in alkalis naturally led the company into chlorine and eventually into a line of plastics. This, in turn, led to petrochemicals, in which the company has a joint operation with Shell. And Saint Gobain's glass interests have carried it into silicones.

All four of these French companies have widespread international interests in foreign manufacturing plants, and receive payments for the rights to manufacture under their patents.

French chemical production rose about 15% in 1958, with an expansion of 40% expected by 1961. Plastics production targets for 1961 are five times the 1958 level. Four new polyethylene plants are under way right now.

▶ **Butyl Rubber, Too**—Five big chemical producers, three rubber manufacturers and two oil companies have joined forces to build in France the first butyl rubber plant outside the North American continent. Capacity of this plant—50,000 tons/yr.—will make France an exporter of butyl rubber.

Estimated petrochemical expansion in France between 1957 and 1959 will be the greatest in all West Europe (see chart, p. 58)—sufficient to bring her capacity somewhat in line with that of Britain and West Germany.

Netherlands

Salt deposits, tidewater geography draw record outlays of chemical capital.

Due to the discovery of new salt deposits, Holland may become one of Europe's major chlorine producers. Her position at the mouth of the Rhine augurs well for the development of a chemical industry adjoining the large oil refineries now there and under construction.

Unfortunately, the Dutch government has aggressively entered the field on its own account, which is not propitious to private investment. Free enterprise, except for Royal Dutch Shell, Unilever and the large synthetic fiber combine, AKU, is represented in the chemical processing field by some 500 small companies.

▶ **Chemical Drive** — Nevertheless, for the first time in Dutch history, investments by the chemical industry have ousted those of the metal industry from first place—380 million guilders vs. 338 million guilders in 1958, or 32% of total industrial investment.

Chemical production rose nearly 8% in 1957 over 1956, largely due to expansion and establishment of big new chemical centers like the ones at Pernis (Royal Dutch Shell) and Delfzigl (Royal Netherlands Salt and Soda Industry).

Rapidly expanding, too, are State Mines' chemical plants, Ketjen Sulfuric Acid & Cata-

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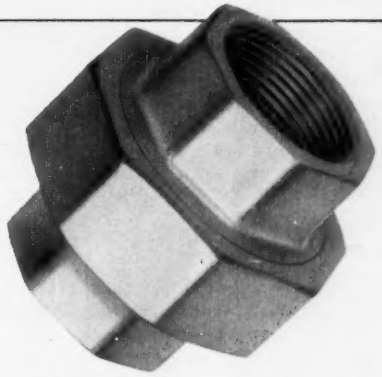

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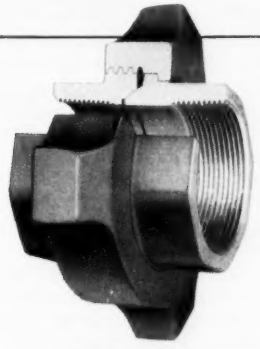

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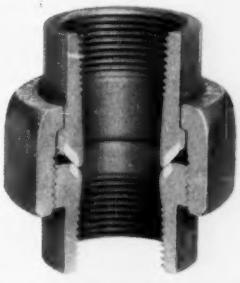

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lysts and pharmaceutical firms like Organon and Philips Roxane.

Recent announcements show Royal Sulphuric Acid Works setting up a carbon black plant (Ketjen Carbon, Ltd.) based on patents and know-how licensed from Godfrey Cabot. And the Dutch firm of Albatros Superfosfaatfabrieken will build, together with Cyprus Mines of Los Angeles, "one of the largest sulfuric acid plants in the world," at Pernis, near Rotterdam.

Home of coke ovens and the Solvay empire, Belgium leans to heavy basics.

Belgium

Belgium's chemical efforts run largely to heavy basics, with a line of coal tar products flowing from her coke ovens. The original Solvay process (1863)—still the standard method for making soda ash—came from a Belgian, Ernest Solvay. Until his patents ran out, Solvay made alliances with most of the big alkali makers and users around the world, including Allied Chemical, Wyandotte and Owens-Illinois in the U.S.

▶ **Accent on Coke Chemicals**—Belgium's production of ammonia from coal naturally brought her into nitrogen fixation when this technique was mastered, so that today she is one of Europe's leading exporters of nitrogen and phosphate fertilizers.

Like so many other European countries, Belgium also has a dominating broad-based chemical company known as Union Chemique Belge. She is also the home of the large photographic materials producer, Gevaert, whose products are widely exported.

Another Belgian firm, Petrochim, is undertaking, together with Union Carbide, a 30-million-lb./yr. polyethylene project which will be operating by 1960 near Antwerp.

Belgium lies in the middle of a consumer market. Over 165 million people are said to live within 300 miles of Antwerp.

Short of raw materials, Switzerland relies on finesse with fine chemicals.

Switzerland

Switzerland, because of a lack of raw materials, has not developed a heavy chemical industry. However, it is the home of four old fine chemical companies which are world renowned for their dyes and drugs: Ciba, Geigy, Hoffman-LaRoche and Sandoz.

Ciba, the largest of these, has an international ethical drug business, besides being very strong in textile accessories and premium plastics. It was the developer of reserpine, our first blood pressure regulant, and has a leading position in epoxy resins and adhesives.

Ciba operates two large plants in New Jersey to supply the American market.

▶ **Long History**—Geigy is probably the oldest single chemical company of record. Its lineage dates back to 1785, when its founders were chemical dealers. It, too, has been intimately tied up with the textile trade of Western Europe.

Geigy is also prominent in pesticides, which are frequently very complex chemicals akin to drugs and dyes. Geigy claims the first discovery and development of DDT without which our last world war would have been an even more horrible story.

Coupling aggressiveness and licensed know-how, Japan builds chemical power.

Japan

Japan is very actively building a chemical industry strongly emphasizing petrochemicals. Nearly a billion dollars was spent on chemical expansion and modernization between 1951-1958. Only power and steel industries significantly exceeded this rate.

Nearly 20% of this—$193 million—went into petrochemicals, to create virtually a new industry, nonexistent before the war.

Japan is believed to be the world's second largest producer of synthetic fibers, third largest for nitrogen and fourth largest for plastics.

▶ **Help From Abroad**—Japanese chemical producers solved their need for technological help by tying up with foreign licensors. Mitsui has an agreement with Karl Ziegler, Sumitomo with ICI. Mitsubishi is in a 50-50 venture with Monsanto for production of polystyrene and polyvinyl chloride film. Showa Denko is affiliated with Phillips Petroleum, as is Furakawa with Standard of Indiana.

Oronite (Standard of Calif.) and Nippon Petrochemicals are planning an alkyl benzene plant.

Sumitomo Chemical may be the largest single Japanese chemical company. Although its sales in yen are equal to only $85 million a year, it must be remembered that prices in Japan are much lower than in the U.S.

Sumitomo, although only 33 years old, has a line which runs from fertilizers and plastics to dyestuffs and pharmaceuticals, and produces a synthetic fiber called Exlan, reported to be the most wool-like of its kind.

Toyo Koatsu is one of the world's largest producers of urea and ammonium sulfate, accounting for 20% of Japan's sulfate output and 35% of her urea capacity.

▶ **Zaibatsu Splinters**—As for other offshoots of older industrial empires,* Mitsui Petrochemicals has started up a terephthalic acid plant, part of a $30-million project for ethylene oxide-glycol, cumene and *p*-xylene. This year Mitsubishi Chemical went into polyethylene and styrene monomer production. Mitsui Petrochemical and Sumitomo Chemical went on stream last year to produce polyethylene.

And the so-called Kawasaki group—Nippon Geon, Showa Chemical, Furukawa Chemical, Mitsubishi Oil, Nippon Catalyzer, Nippon Petrochemical and Asahi-Dow Chemical—began last month to produce the same line of petrochemicals as Mitsui and Sumitomo.

* Sumitomo Chemical, Mitsubishi Chemical, Mitsui Chemical, etc., are splinter groups formed from the breakup of the colossal pre-war "zaibatsu" combines bearing the same names.

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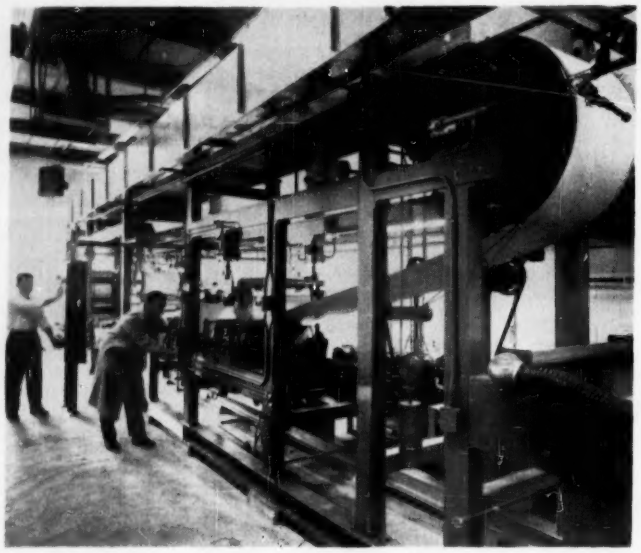


Full-Sized Paper Coater Assumes Role of Lab Tool

To run experimental tests of new paper coating materials under highly realistic mill-operating conditions, National Starch & Chemical Corp. has just installed a 45-ft.-long paper coater in its Plainfield, N. J., laboratory.

Basically similar to full-size mill equipment, it has a flexibility not found in its work-horse brothers. It can be set up to do all six major types of coating and sizing operations: air knife, trailing blade, roll, reverse roll, size press, and modified size press. Rolls for gravure and offset gravure coating will soon be added. The machine can run 22-in. wide paper rolls through its various stations at speeds up to 2,000 ft./min.

Its primary use will be for determining the machining characteristics of starch or synthetic resin coatings, both of which NS&C supplies to the paper industry. — National Starch & Chemical Corp., New York. 66A

Silicone

Key to new process which permits dyeing of glass with 14 dye types.

A new process permits the use of 14 different classes of dyes on glass cloth. Heretofore, glass fabric dyeing has been limited to the use of selected pigments.

The new process, called Silrama, utilizes the tenacious affinity of the new organo-functional silicones for glass and the chemically reactive nature of the pendant groups of these new chemical molecules.

The process permits successful application of such water-soluble dyes as vats, vat esters, vat acids, acid wools, sulfurs, directs, naphthols, direct and developed dyes, pre-metallized acids and neutrals, and the new reactive dyes.

Preliminary tests of new deep shade obtained show marked improvement in alternate light and wash fastness. Solvent resistance is an additional advantage.

The process is now available for licensing.—**Union Carbide Silicones Div., New York. 66B**

Amino-Silane

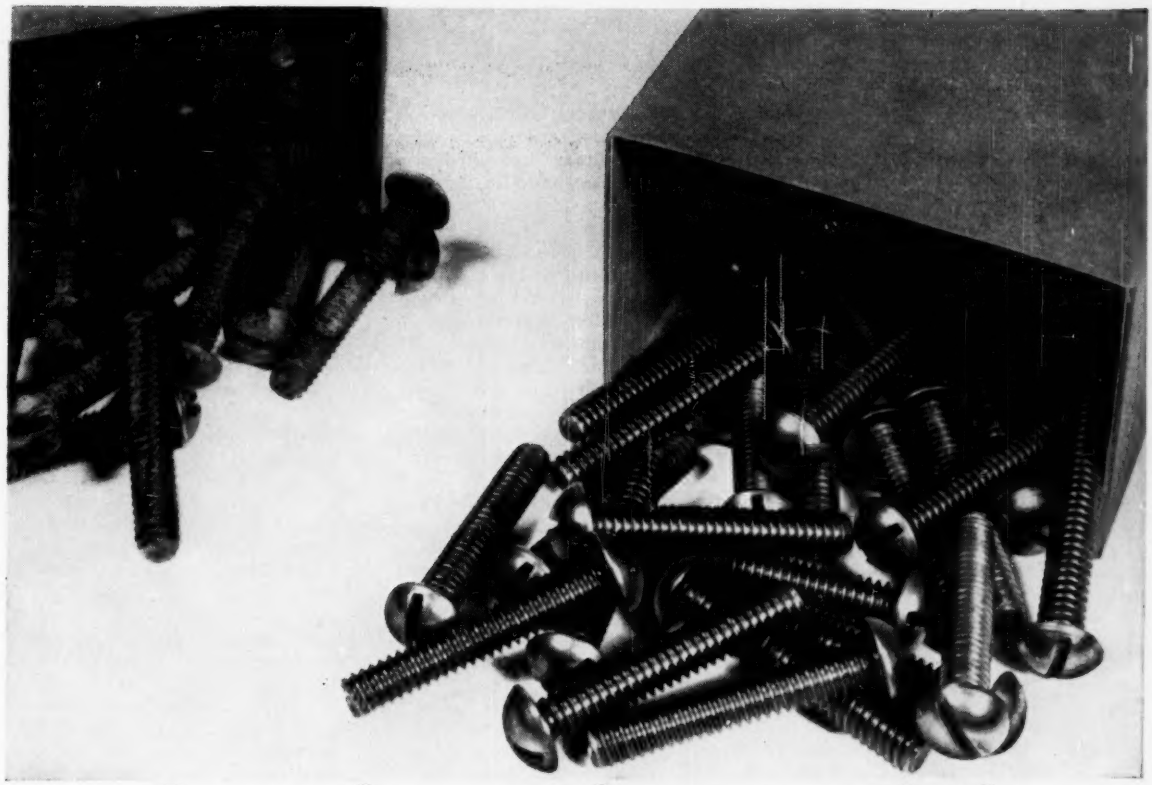
Reacts with both organics and inorganics, strongly binding them.

A new amino-functional silane called Z-6020 contains in its molecule primary and secondary amine groups which will combine with organic materials such as phenolic, epoxy or melamine resins, organic adhesives and common dyes. When it is dissolved in water, hydroxyl groups form on the silicon atom. These will attach to inorganic materials such as glass, minerals or metals. Most of the applications of Z-6020 are based on this ability to serve as a bridge between organic and inorganic materials.

Addition of Z-6020 to the phenolic resin binders for glass fibers and mineral wool significantly improves the wet strength of the insulation. It increases the resiliency of bulky, low-density insulation products.

Properties	
Physical form	liquid
Color, max	brown
Visc. @ 25 C	5–15 centistokes
S.G. @ 25 C	1.03–1.06
Refr. Ind. @ 25 C	1.45
Neut. Equiv.	118.5
Solubility	In most solvents
Shelf life	>8 mo.

The new product is said to improve the heat resistance of pipe and blanket insulation, and



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helps extend the temperature range over which it can be used. Strength of insulation products treated with Z-6020 is somewhat improved. This may make possible a slight reduction in the resin content of certain insulation products.—**Dow Corning Corp., Midland, Mich.** 66C

Magnesium Hydroxide

High concentration in which it's now available brings cost down.

Magnesium hydroxide, is now available in a 60% concentration as a result of improvements in processing. This is the first time a concentration this high, of pumpable consistency, has been produced commercially. Formerly, 52% was the most concentrated form.

Improvements in processing center around better stabilization to minimize the settling of solids. The result is a fluid, stable suspension which lends itself to tank-car shipment.

A chemical intermediate, magnesium hydroxide finds its primary application as a raw material for magnesium base pulping in the paper industry, including the Magnefite process.

The net effect of the higher concentration material will be a lower delivered cost to customers, who will be receiving less water and approximately 25% more usable solids.—**Dow Chemical Co., Midland, Mich.** 68A

Polyepoxides

Exceptional for functional purity, increased reactivity, and for low cost.

The first of a new series of high purity epoxidized fatty esters are being produced by a new process allowing up to 96% conversion of unsaturated fatty esters to epoxides. These products mark Swift's entry into the plastics field.

These reactive polyepoxides differ from conventional bisphenolepoxy resin types in functional purity, increased reactivity and lower cost. The more toxic and allergenic amine curing agents are not effective while it is possible to use dibasic acids, anhydrides and acid catalysts.

Epoxol 7-4 is the first and is produced from soybean oil. It is characterized by a 7% oxirane oxygen and 4 epoxide groups per molecule. The new process by which it is produced minimizes the formation of hydroxylated and polymeric byproducts. For this reason Epoxol 7-4 is low in viscosity and is more compatible with nonpolar resins (particularly polyvinyl chloride). The reduction of byproduct formation results in a corresponding increase in the oxirane oxygen content giving a product with higher functionality.

The compound will be of interest to manufacturers of resins and coatings in which the reactivity of the epoxy groups with many types of acids can be utilized. Combinations with many types of resins are possible because of the compatability of these epoxy fatty esters. In addition, they can be of interest as acid acceptors for use in corrosion inhibition and stabilizing plasticizers for resins.—**Swift & Co., Hammond, Ind.** 68B

BRIEFS

Polyvinyl chloride and vinyl acetate combination called Marvinol VR-60 is said to have have a softness which permits record makers to mold exacting reproductions of the metal master record. The result is high fidelity reproduction with low background noise level. — **U.S. Rubber Co., New York.** 68C

Liquid spreader-sticker made with polyethylene and called Plyac is said to give agricultural pesticide sprays spreading and sticking properties never before possible.—**Allied Chemical Corp., New York 6, N. Y.** 68D

Phosphinoborines, a newly-synthesized molecule described as a linear chain of repeating, tetracoordinate phosphinoborine units with a molecular weight of about 12,500, may lead to the development of heat stable plastics. They are expected to stand heats of 750 F.—**American Potash & Chemical Corp., Los Angeles, Calif.** 68E

More dyeable version of Darvan, textile fiber prepared from

Newsworthy Chemicals

Page Number is also Reader Service Code Number

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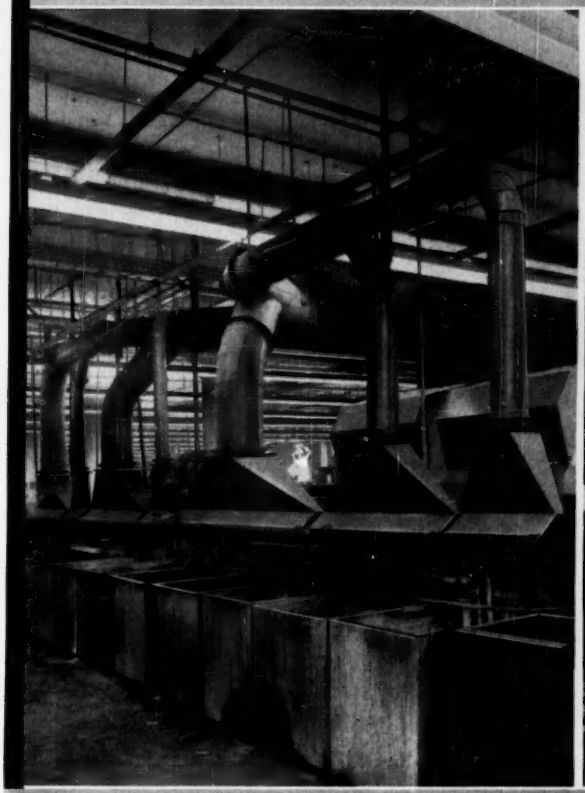

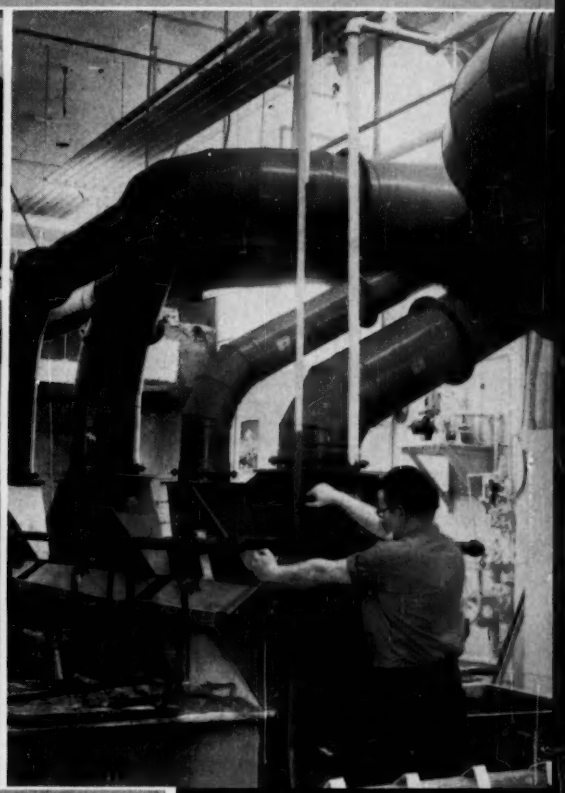

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Water-Based Acrylic Paint, Four Years Later

Water-based acrylics for outdoor use over wood, as well as masonry, are just now getting full commercial endorsement from several major paint manufacturers (Chem. Eng., June 1, 1959, p. 38). But suppliers of acrylic vehicles (like Rohm & Haas with Rhoplex AC-33) have been sold on the idea long enough to accumulate some solid monuments to the paints' effectiveness.

The pine clapboard house above shows two coats of the new paint in very good condition after a four-year exposure to Philadelphia weather. In this case, very old oil paint on the original surface was simply brushed down before application of the water-based acrylic. But, for the present, manufacturers of acrylic vehicles and of the paints are recommending use of linseed oil primers.

Some of the paints' rewards: Ease of application; dry-to-touch in 30 min.; unmatched resistance to fading, yellowing, cracking, and blistering.—**Rohm & Hass Co., Philadelphia.** 70A

a polymer containing vinylidene dinitrile (formerly described as a dinitrile, Darvan is at present the only member of a new generic class, the nytrils, created by the FTC's new fiber labeling act), has been developed. While pastel and medium shades of dyestuffs have been easily handled with standard methods on Darvan, the fast deep shades have required a high temperature dyeing which has restricted the range of colors available. New Darvan X-7 can be dyed a wide range of colors at boil.—**B. F. Goodrich Chemical Co., Cleveland, Ohio.** 68F

Linking polyethylene's long-chain molecule with that of another (unidentified) plastic is said to produce a new molding compound with exceptional low-temperature qualities, a flex life five times longer than existing molding materials, greater rigidity and superior resistance to cracking. Called DPD-7365, it is expected to get its first use in garbage cans; as such, it has withstood 6-ft. dropping tests at −10 F.—**Union Carbide Plastics Co., New York, N. Y.** 70B

Catalyst used in selective hydrogenation of acetylene in raw ethylene streams, a promoted cobalt molybdate on an improved carrier, is said to increase output and reduce operating costs. Called G-54, it inhibits polymer formation, extending cycles between regenerations to 30 to 40 wk.—**Girdler Catalysts, Louisville, Ky.** 70C

Ethyl isocyanate and phenyl isocyanate are now commercially available from Carwin. Shortly, aliphatic diisocyanates and higher molecular weight aliphatic monoisocyanates will also be available.—**Carwin Co., North Haven, Conn.** 70D

Two polystyrenes with superior color stability under fluorescent light radiation have been announced. Marketed as Styron 672 Verelite for molding and Styron 673 Verelite for extrusion, the products are expected to find use in diffusers, fixtures and grids.—**Dow Chemical Co., Midland, Mich.** 70E

New adhesive called Hysol 2527 provides strength at 300 F. and above. The smooth, thixotropic paste will not flow during cure, even when applied to a vertical surface. It is 100% solids and suited for bonding both porous and nonporous surfaces.—**Houghton Laboratories Inc., Olean, N. Y.** 70F

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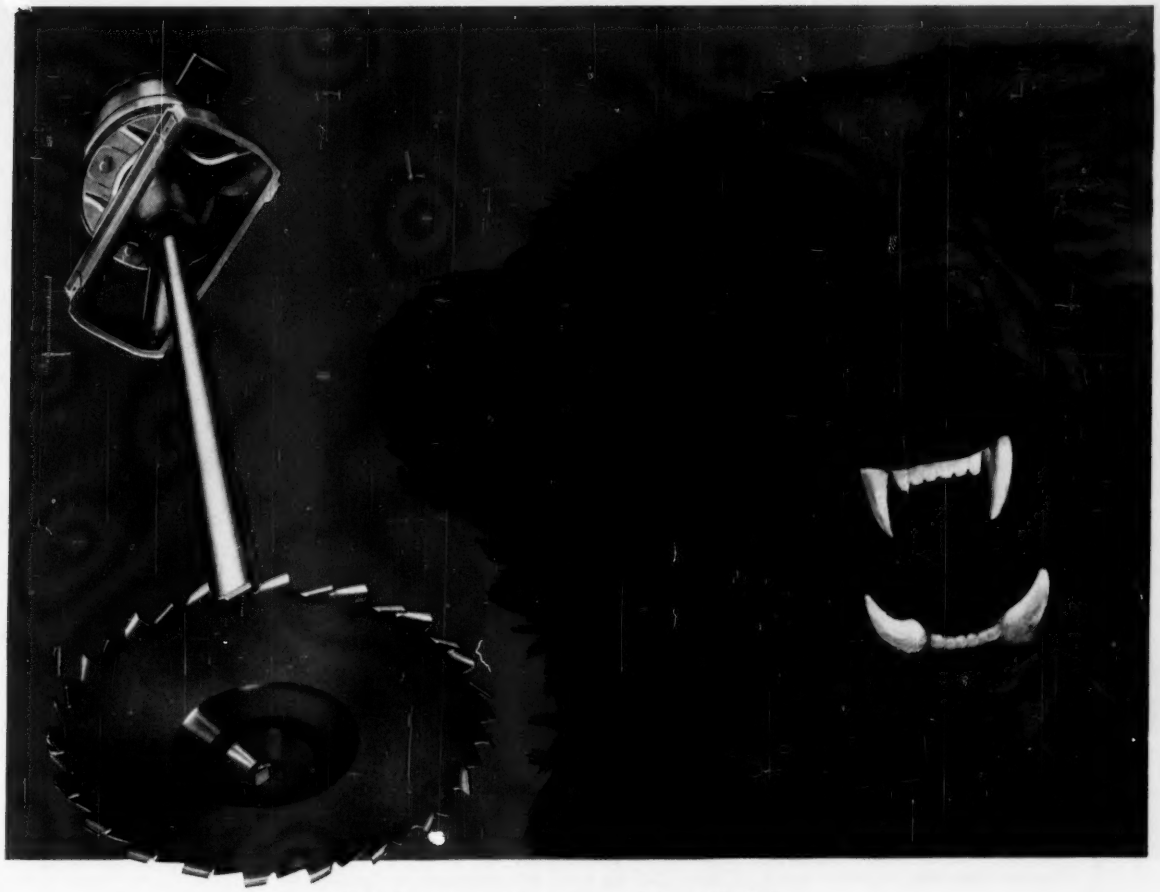

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Powdered metallic lead is being thoroughly dispersed in batches of 700 lbs. to 10 gals. of mineral spirits...in a few minutes! No recourse to time-consuming ball mill. Great saving in space, too, and probably a record in lbs.-per-gal. dispersion.

Mastic compounds in minutes
High viscosity mastic compounds that used to take hours via old "Z" blade methods, are now prepared in minutes with the Cowles. The Cowles delivers maximum horsepower at all impeller speeds.

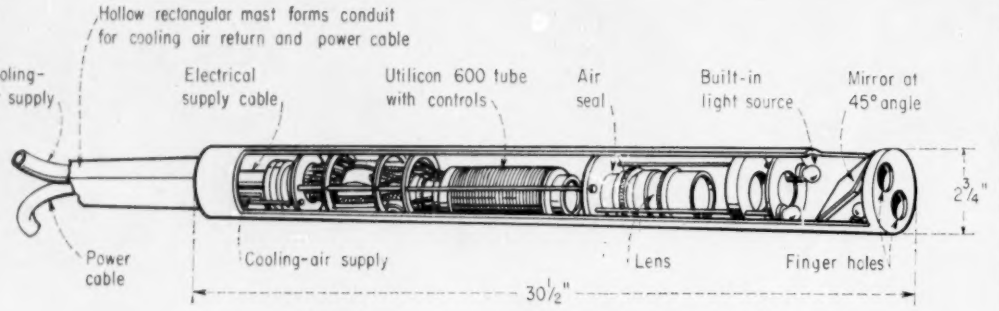
Paper coatings are more stable
Nitrocellulose paper coatings are made simply by adding the nitrocellulose cotton to the dilutent in the tank, pausing for a brief soak-wet down period, then adding the active solvent while the Cowles is in motion. Result: an excellent, highly stabilized solution without the problems of drifting viscosities. In operation, there's no surge, no splash.

Pipe and joint compounds speeded
Grease pipe and joint compounds that formerly took hours when mixed by "Z" blade are now being made in minutes with the Cowles. The Cowles "hydraulic attrition" action speeds many processes to an astounding degree.

DEVELOPMENTS . . .

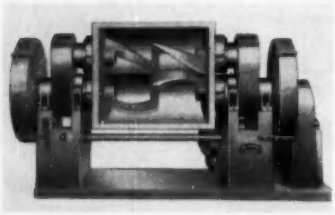
PROCESS EQUIPMENT

EDITED BY C. C. VAN SOYE



Pencil-Style TV Camera Views Tubing From Within

Built to operate inside 3-in. tubing, this new closed-circuit television camera enables critical inspection of atomic-reactor tube welds while the tubes are still in the pile. Stainless steel reactor tubes blacken under radiation, but defective welds remain clean and show as white areas on the 17-in. monitor. Both monitor and the camera control power unit, which complete the closed-circuit system, are cart-mounted for ease of movement to inspection sites. Though not suggested by the manufacturer, the camera may find application in some furnace tubes, process lines, etc. Electronics Div., Diamond Power Specialty Corp., Lancaster, Pa. 72A



Mixers

Design improvements prolong service life.

A new line of mass and paste mixers embodies several improvements in construction that assure long service under severe operating conditions, freedom from contamination and a minimum of maintenance.

Double rows of lubricated bearings give the shafts maximum effective support for complete rigidity. Improved seals assure freedom from contamination. And gears are protected from dust by guards that remain in place whether the bowl is in the mixing or the dumping position.

Such features as jacketed mixing bowls, vacuum or pressure covers and several different types of blades are optional. Size range is 3 to 300 gal.—**Paul O. Abbe, Inc., Little Falls, N. J. 72B**

Transfer Hose

Small diameters offered now; larger sizes soon.

An abrasion-resistant rubber jacketing reinforced with spiraled wire and lined with Teflon resin is the material of construction for a new transfer hose for corrosion service. Fluids being transferred cannot contact the metal flanged fittings or outer covering. Current production of the hose is limited to 1¼-, 2- and 3-in. sizes. Larger diameters will be available shortly.—**Resistoflex Corp., Roseland, N. J. 72C**

Feeder Controls

Give smooth, stepless adjustment of feed rate.

Syntron has announced development of new controls for its complete line of electromagnetically vibrated feeders. The controls provide continuous,

Designed to give you *Double Protection!*

WAGNER TYPE DP MOTORS

PROTECTED against corrosion...

PROTECTED against splashing liquids...

WM59-9

Wagner Type DP Motors provide *double protection* that means longer life—more versatility of application. Rugged cast iron frames and endplates are highly resistant to corrosion. Dripproof enclosures are so well designed that these motors can handle many applications that formerly required splashproof motors. These motors pack ample power into little space, are light in weight and are easy to maintain.

SLEEVE BEARING MODELS AVAILABLE. The entire line of ratings is available with ball bearing construction, or with steel-backed, babbitt-lined sleeve bearings of high load carrying capacity that provide quieter operation.

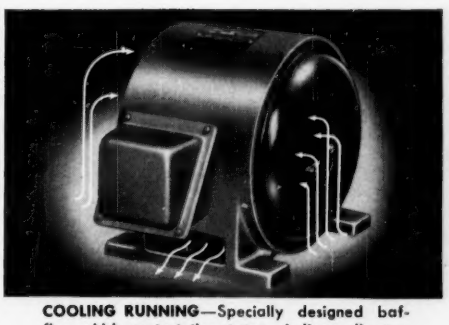
Let a Wagner Sales Engineer show you how these motors can be applied to your needs. Call the nearest branch office or write for Wagner Bulletin MU-223.

Branches and Distributors in All Principal Cities

Wagner Electric Corporation

6407 Plymouth Ave. • St. Louis 14, Missouri

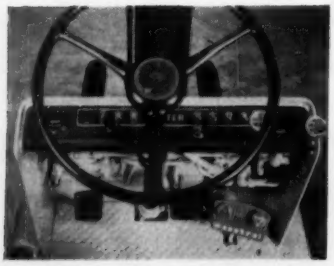
DOUBLY PROTECTED—Air intakes and outlets are positioned to provide complete protection against dripping or splashing liquids. Rugged cast iron frames protect against rough handling and corrosion.



COOLING RUNNING—Specially designed baffles, which protect the stator windings, direct a cooling stream of air through the motor to effectively cool the motor—add to motor life.

CAN BE RE-LUBRICATED—Original factory lubrication will last for years in normal service—but grease plugs are provided to permit re-lubrication that adds years to motor life under severe conditions.

stepless, variable feeding-rate adjustment, from 0 to 100% capacity. All new models from the factory will be equipped with the controls; they are also available for feeders now operating in the field.—**Syntron Co., Homer City, Pa.** 72D



Lift-Truck Control

Enables easier and faster load handling.

In the new Monotrol system for lift-truck control, throttle and forward-reverse direction control are combined in one right-foot pedal—this frees the operator's hands for full-time steering and load-handling control. Dashboard pushbuttons for "Park" and "Drive" govern brake and transmission.

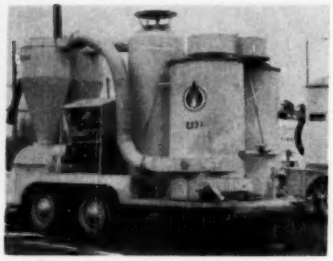
A single foot movement selects direction and controls acceleration. Touching the toe at the left side of the Monotrol pedal shifts the transmission into forward range. Touch the toe pad at the right side of the pedal and the transmission shifts into reverse. Total depression of the pedal at either side accelerates the engine. Another feature of the new system is a left-foot inching-brake pedal. Monotrol comes on the manufacturer's Spacesaver 30, 40 and 50 lift-trucks equipped with Power-Shift Hystamatic transmission.—**Hyster Co., Danville, Ill.** 74A

Valve Operator

Fits manufacturer's line of miniature valves.

Air-loaded springless operators for application on many of the manufacturer's miniature valves can be furnished in normally closed or normally open models, with pressed steel or cast aluminum cases. All models have travel indicators and mountings for miniature switches.

In operation, signal air forces a diaphragm into a sealed, pneumatically-loaded chamber when signal pressure exceeds chamber pressure. Compression of the trapped air in the chamber side of the diaphragm returns the operator to normal position when signal pressure drops.—**George W. Dahl Co., Inc., Bristol, R. I.** 74B



Gas-Main Cleaner

Looks like armored car but stops piping blockages.

Displaced scale and residue accumulating in gas piping reduces flow area, fouls up service nozzles and eventually causes complete blockage of the mains. A "vacuum cleaner" developed by Conveyair can remedy such situations.

Work begins simultaneously at both ends of the pipe to be cleaned. The cleaner is attached to one end, and a mechanical descaling router is worked into the other end. As the router scrapes along, removing all loose material, the cleaning unit sucks it into large built-in holding bins. Between 500 and 1,200 ft. of gas main can be cleaned at a time using this system, according to the manufacturer.

Two sizes of the cleaner are on the market—one for pipes up to 8 in. dia., the other for 16 in. A two-cylinder, 35-hp. engine powers the smaller unit, the other uses 71-hp.—**Conveyair, Inc., Portland, Ore.** 74C

For More Information . . .

about any item in this department, circle its code number on the

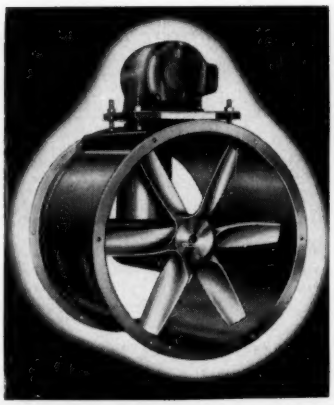
Reader Service

postcard (p. 159)

Gate Valves

Constructed of ductile iron. Corrosion resistant.

Designed to utilize all of ductile iron's unique properties and advantages, a new line of gate valves is available in sizes ½ to 2 in. The valves are rated at 1,000 psi. for all temperatures between −20 and 650 F. High strength as well as excellent thermal-shock, impact and corrosion resistance are ductile iron's desirable properties.—**The Ohio Injector Co., Wadsworth, Ohio** 74D

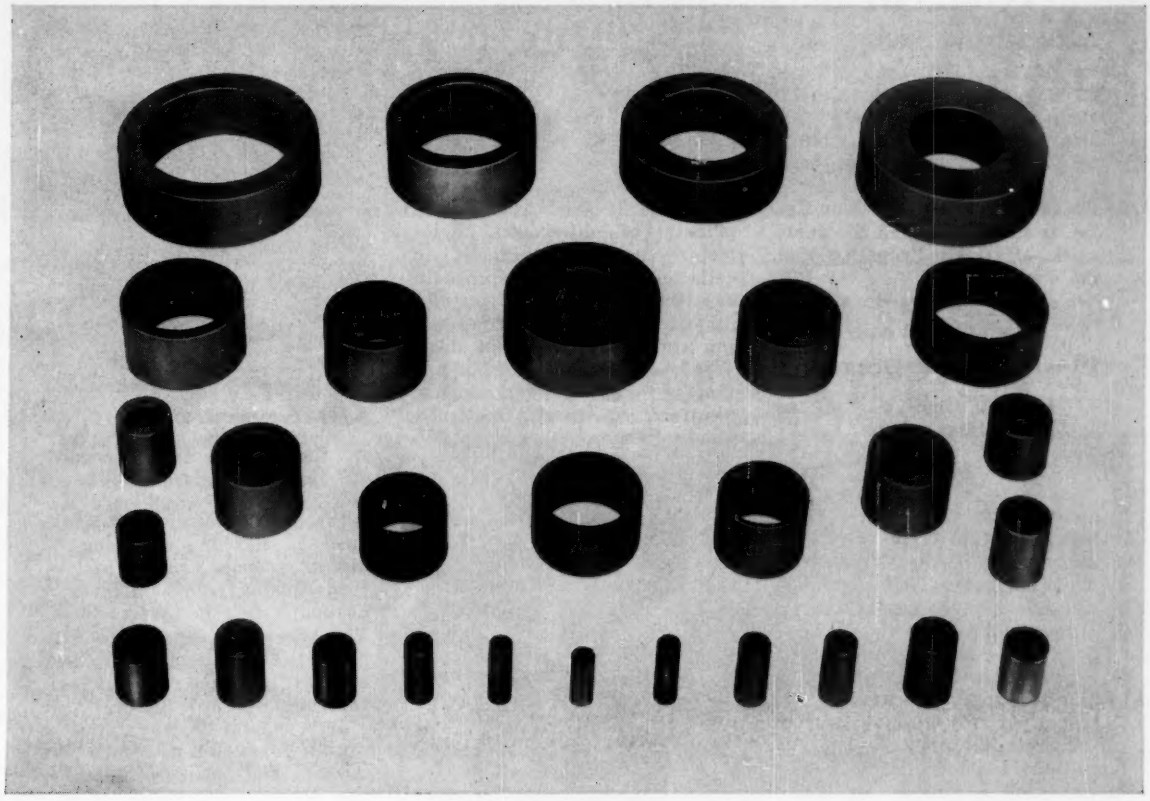


Duct Fans

Feature easily adjustable variable drives.

Variable-pitch drives that permit quick and easy adjustment of fan speed are standard items on the redesigned line of Hartzell belt-drive duct fans. Simple adjustment of the driver sheave on these new fans will cut speed to reduce air deliveries up to one-third.

A second feature of the line



2 ways to save on pressure tubing

1. GET TIMKEN QUALITY STEEL

When you get Timken® steel pressure tubing, you get the finest quality tubing your money can buy. Quality that assures long, economical service. And it begins in the Timken Company mill with fine alloy steel, melted in the most modern electric furnaces in this country. Experts in melting, piercing, finishing and inspection guard this quality for you using many procedures that are virtually unique in the steel industry. For example, *all* tubes are specially conditioned to assure finer finish. And backing all this technical ability are 30 years of experience in producing pressure tubing. The result is quality that assures you *the longest tube life per dollar.*

2. LET TIMKEN COMPANY EXPERTS HELP SOLVE YOUR PRESSURE TUBE PROBLEMS

Whatever your steel pressure tube problems—corrosion, oxidation, heat, pressure—Timken Company steel experts can help solve them. They've solved hundreds of the toughest problems in every field, from steam generators to chemical plants. From the wide range of diameters and wall thicknesses available in Timken pressure tubing, (typical examples shown above) we can select the most economical size in the right analysis for your needs.

Get quality pressure tubing that will save you money. Specify Timken steel pressure tubing. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*

WHEN YOU BUY TIMKEN STEEL YOU GET . . .

1. Quality that's uniform from heat to heat, bar to bar, order to order
2. Service from the experts in specialty steels
3. Over 40 years experience in solving tough steel problems

TIMKEN® *Fine Alloy* STEEL

TIMKEN ALLOY STEEL AND SEAMLESS TUBING IS AVAILABLE FROM WAREHOUSE STOCK IN 44 CITIES IN THE UNITED STATES

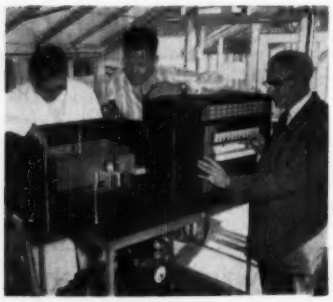
is complete standardization of components within each fan size. Thus, a change of motors to meet changing air delivery requires no modification of the fan, and can be done while the fan is still in place in the ductwork.—**Hartzell Propeller Fan Co., Piqua, Ohio** 74E

Plastic Piston Ring

Last 20 times as long as conventional rings.

Fabricated from a reinforced Teflon resin, self-lubricating piston rings for compressors last more than 20 times as long as conventional cast iron rings when exposed to wet hydrogen. According to the manufacturer, a single ring takes the place of four of its metal counterparts.

Easily withstanding pressures as high as 4,500 psi., the rings perform well over a wide temperature range—from −320 to 500 F. The rings were first exhibited at the recent World Petroleum Congress. — **E. I. du Pont de Nemours & Co., Wilmington, Del.** 76A



Fluoride Recorder

Measures concentrations as low as 0.1 ppb.

Companies discharging fluorides to the atmosphere can use a new instrument to record short-term variations of gaseous fluoride concentration in specific plant areas. Conventional methods of fluoride monitoring require several hours to accumulate a measurable amount of fluoride, thus giving only long-term averages. The new recorder shown above, developed at the Stanford Research Institute, measures concentrations as low as 1 or 2 parts per ten billion, and in only a few minutes.

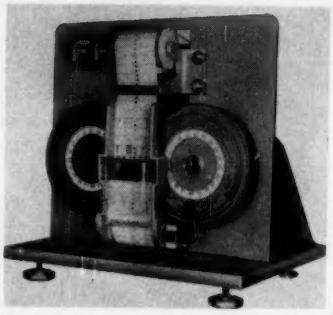
SRI's recorder works on the principle of a differential photometer—that is, photoelectric cells measure the difference in reactions on adjacent areas of a fluorescent tape. Fluoride-bearing air reacts on one of these areas; a fluoride-free standard reacts on the other area.—**Stanford Research Institute, Menlo Park, Calif.** 76B

Neutron Source Vessel

Stores radioactive sources for tests or teaching.

Model NH-2 Neutron Howitzer is a new device for storing neutron sources and teaching nuclear physics. The Howitzer consists of a 35- x 23-in.-dia. aluminum vessel filled with 350 lb. of paraffin. It is shipped complete with source-handling tongs, two BF_3 detector mounts, and a variety of foils, foil holders and lucite spacers that fit two cadmium-lined port drawers.

Model NH-2 falls into the categories of equipment for which the U. S. Atomic Energy Commission will consider grants of financial aid to educational institutions.—**Nuclear Chicago Corp., Chicago, Ill.** 76C



A/D Recorder

Supplies a digital record from analog signals.

Fischer & Porter has developed a shaft-input analog-to-digital recorder (ADR) that records analog values in binary-decimal, punched-tape form. The tape can be read directly, or translated automatically into standard punched cards or tape for computer processing.

In addition to supplying a digital punched-tape record, the ADR simultaneously supplies the digital information in the form of electrical contacts that may be used for telemetering. ADR operates from commercial power supplies or from a 6-v. dry-cell battery.—**Fischer & Porter Co., Hatboro, Pa.** 76D

Viscosity Control

Instruments for use when record not required.

Norcross Corp. has supplemented its viscosity instrumentation line with a new indicator and an indicating controller. These models provide viscosity control at a lower cost for applications where a permanent record is not required.

Used with the company's basic measuring elements, the indicator and indicating controller can be located any reasonable distance from the measuring element, and can be

EQUIPMENT NEWS
Continues on..... Page 144

Items of Interest to the Processing Industry

WOLVERINE TUBE

PUBLISHED BY WOLVERINE TUBE

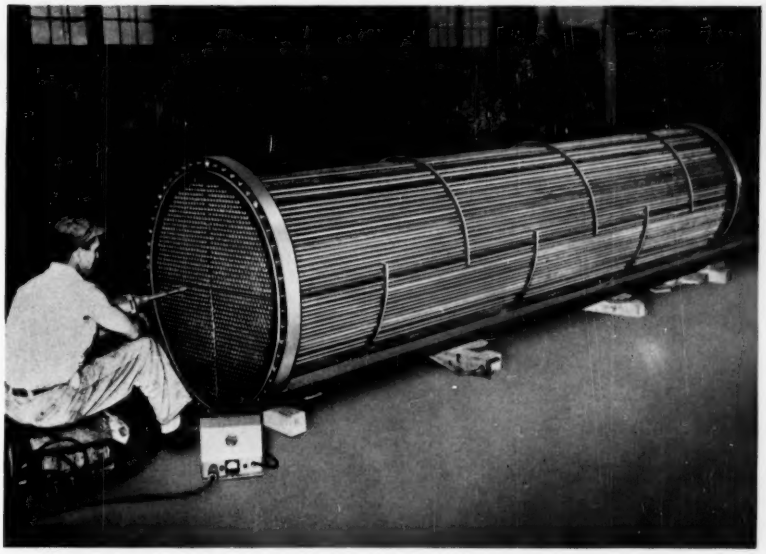
SOUTHWEST CHEMICAL COMPANY SAVES $50,000 BY USING WOLVERINE TRUFIN® TYPE S/T

BY ERNEST DODD

Fifty thousand dollars is a lot of money . . . yet this is the amount saved by a large southwestern chemical company when it used Wolverine Trufin Type S/T condenser tubing to solve a specific heat transfer problem.

In this case, refinery engineers desired to increase the throughput of a given operation. However, a survey revealed that to get the necessary increase would require doubling the heat exchanger surface.

This would have required another heat exchanger as large as the existing unit along with additional space and structure. This naturally involved considerable money.



However, a study of the problem revealed that by redesigning the existing bundle and retubing with Wolverine Trufin Type S/T — the original, integrally-finned condenser tube — the need for the additional equipment would be eliminated. This was done using Trufin Type S/T in pure nickel form. Savings in time, labor and materials have been estimated at more than $50,000.

This is but another in the long list of authenticated examples of the outstanding heat transfer job that Wolverine Trufin Type S/T is doing throughout American industry. Why not get the complete story for yourself? Write for the Trufin Catalog or talk to one of Wolverine Tube's highly-trained heat transfer sales specialists. Their names, addresses and telephone numbers are listed on the reverse side of this page.

ADMIRALTY TRUFIN OFFERS 13% BOOST IN SURFACE AREA

Does your heat transfer operation require Admiralty condenser tube in integrally-finned form? *Then here's good news for you!*

Now — thanks to Wolverine Tube's continuous research program — it is possible to obtain a 13% increase in outside surface area of Trufin Type S/T Admiralty condenser tube.

This increase is made possible through the development of a readjusted fin contour that permits Admiralty Trufin to compare favorably in outside surface area with copper Trufin Type S/T.

As a result, shell and tube units, where Admiralty Trufin Type S/T is used, can gain a significant increase in outside surface area which in turn means a significant increase in total heat duty handled or a decrease in the size of the exchanger or both.

This is a point well worth remembering if you are about to retube existing units or are considering the design of new equipment.

TRUFIN TYPE S/T IDEAL FOR USE IN NEW OR OLD UNITS

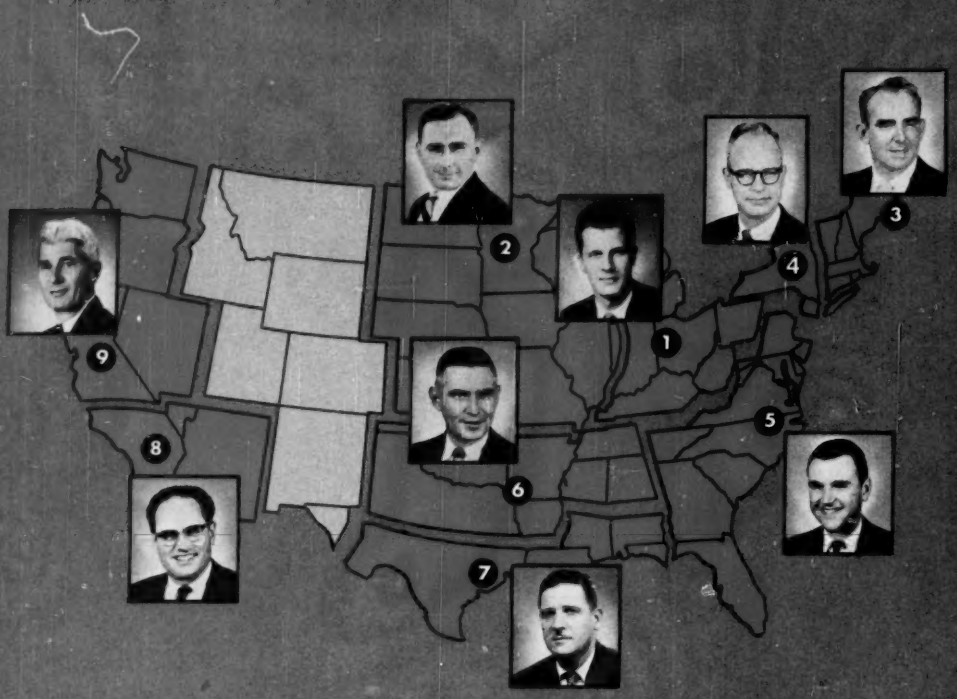
Wolverine Trufin Type S/T is finding ever increasing acceptance in the chemical, petro-chemical and petroleum refining fields . . . for use both when retubing existing equipment or designing new units.

Retubing an existing heat exchanger can be accomplished, in many instances, simply by directly substituting Trufin Type S/T for prime surface tube. Because its integral fins give it greater outside surface area Trufin packs more heat transfer surface into a given space thus steps up the capacity of existing units.

When new equipment is being designed Trufin Type S/T permits the design of smaller, more effective units with a direct saving in materials, time and labor. Trufin Type S/T is widely used in naphtha condensing, butylene condensing and lube oil cooling—is particularly effective in handling light hydrocarbons.

Wolverine Trufin is available in Canada through the Unifin Tube Division, London, Ontario, Canada.

NEED HELP WITH HEAT EXCHANGER PROBLEMS? LET THESE SPECIALISTS SERVE YOU



Each of these men is a highly-trained specialist in the field of heat transfer. If you have a problem concerning such things as design, corrosion, alloy selection, where and when to use integrally finned tube, etc.—don't hesitate—give the one nearest you a call. You can depend fully on his heat transfer knowledge.

1
R. B. DAVIS
8941 Schaefer Hwy.
DETROIT 28, MICH.
WE 1-0783—1-0787

2
M. A. WALLACE
P. O. Box 569
EVANSTON, ILL.
DA 8-8616

3
J. E. O'CONNOR
Room 4004
60 E. 42nd St.
NEW YORK 17, N.Y.
MU 2-8430

4
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Room 4004
60 E. 42nd St.
NEW YORK 17, N.Y.
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5
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Liberty Trust Bldg.
Broad & Arch Sts.
PHILADELPHIA 7, PA.
RI 6-1442—6-1443

6
W. K. MASONER
605 Mayo Bldg.
TULSA 3, OKLA.
GI 7-3500

7
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Corner of Commerce
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Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES

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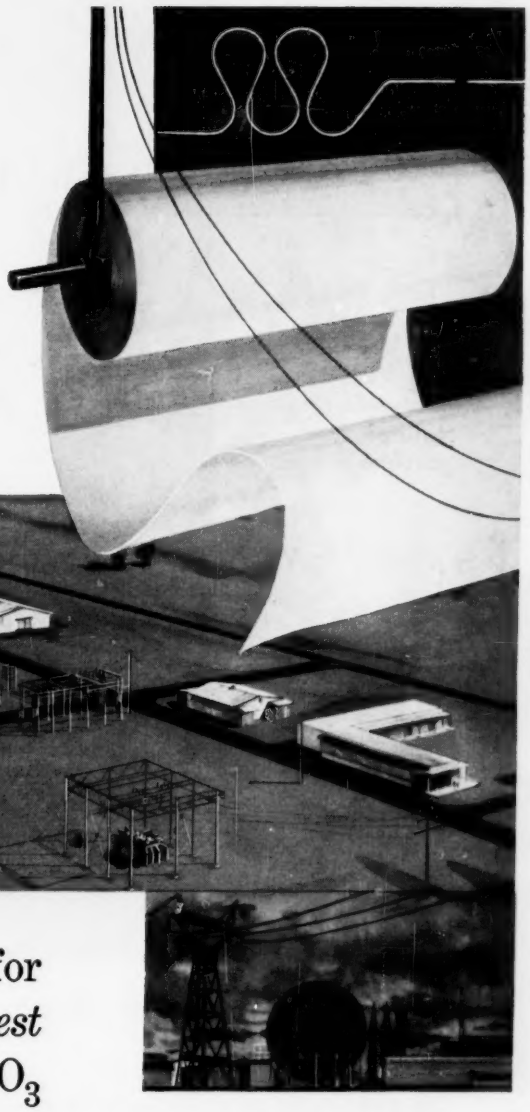
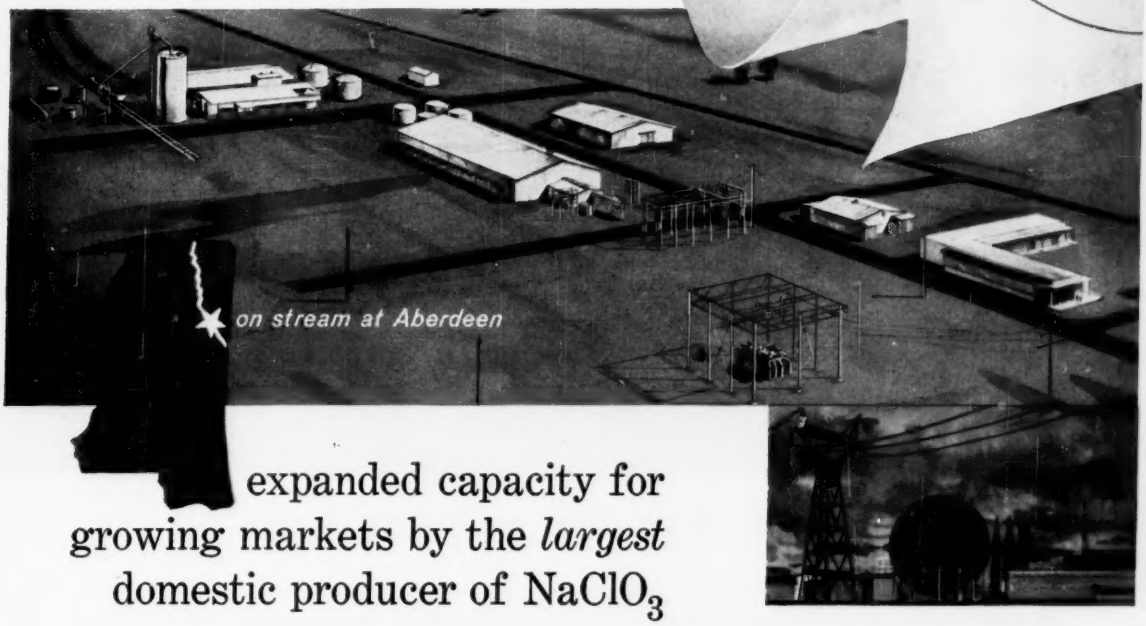
SODIUM CHLORATE
from Aberdeen, Mississippi





expanded capacity for growing markets by the *largest* domestic producer of $NaClO_3$

The big news in sodium chlorate is TRONA's new electrochemical plant, now on stream at Aberdeen, Mississippi. This latest AP&CC facility provides faster and better service to the South's growing pulp and paper production centers, as well as further assurance of dependable sodium chlorate supply for other important markets in such fields as agriculture, uranium ore processing and solid propellant fuels. Aberdeen's readily expandable, initial capacity of 15,000 tons per year, added to the $NaClO_3$ production capability of Trona's Henderson, Nevada, plant makes American Potash & Chemical Corporation the largest domestic supplier of sodium chlorate...capable of meeting *all demands* from expanding commercial and military users. ***Further information on Trona's sodium chlorate service and production capabilities at Aberdeen is available from your nearest AP&CC branch office.***

TRONA

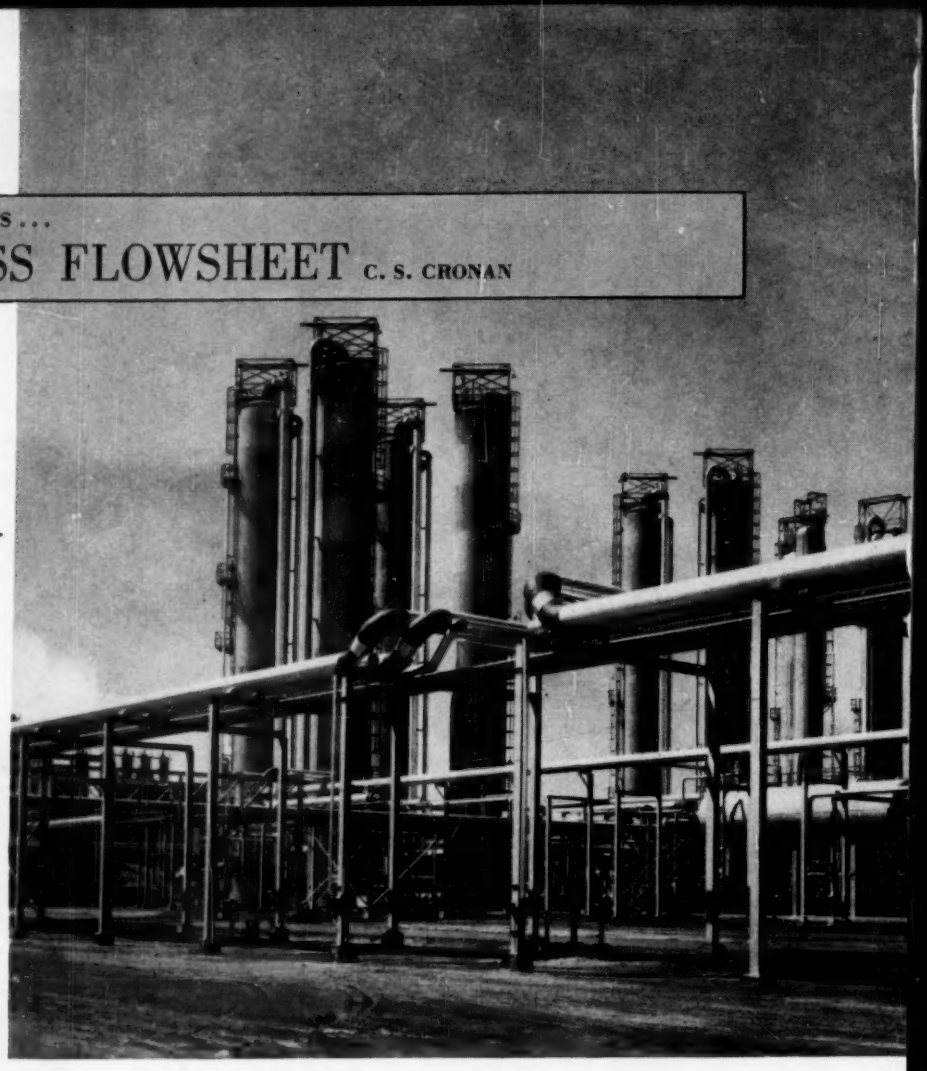
American Potash & Chemical Corporation

3000 WEST SIXTH STREET, LOS ANGELES 54, CALIFORNIA
99 PARK AVENUE, NEW YORK 16, NEW YORK
OFFICES: LOS ANGELES, NEW YORK, CHICAGO, SAN FRANCISCO, PORTLAND (ORE.), ATLANTA, COLUMBUS (O.), SHREVEPORT

Producers of: BORAX • POTASH • SODA ASH • SALT CAKE • LITHIUM • BROMINE • CHLORATES • PERCHLORATES • MANGANESE DIOXIDE
THORIUM • CERIUM • RARE EARTHS • *and other diversified chemicals for Industry and Agriculture*

DEVELOPMENTS . . .

PROCESS FLOWSHEET C. S. CRONAN



Mixed pentanes from natural gasoline feed oil's first commercial . . .

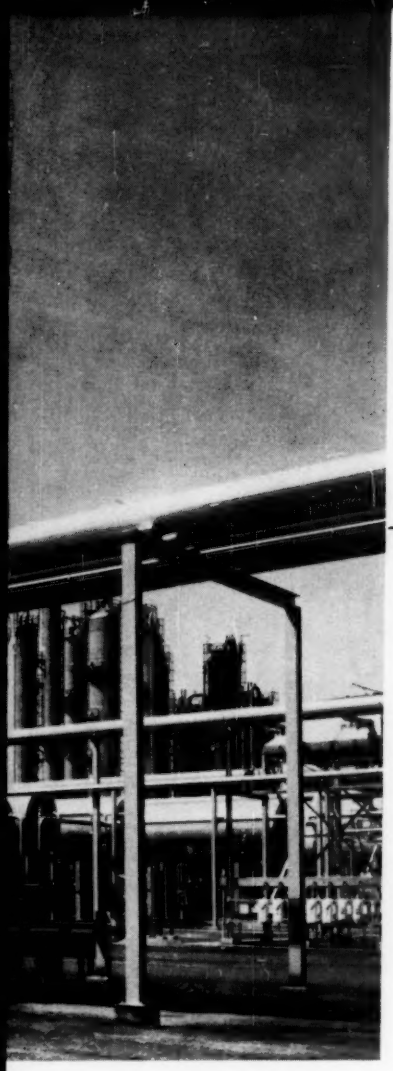
Pentane Isomerization Unit

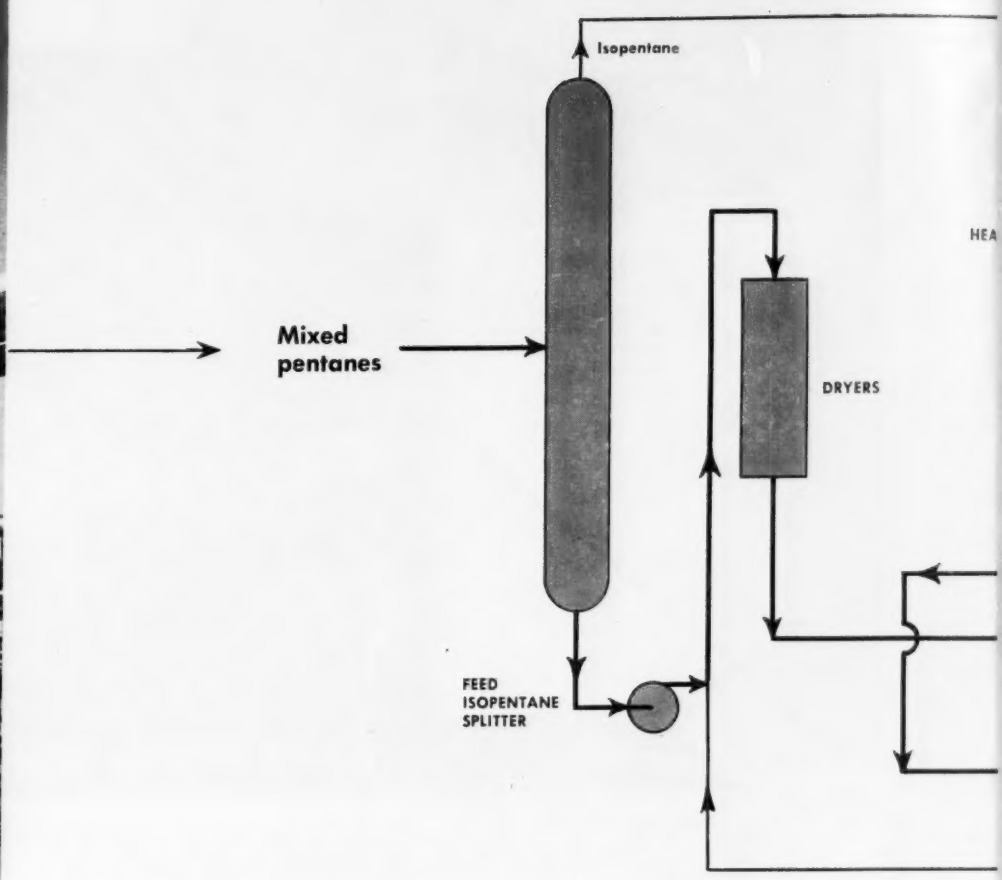
. . . to boost octane of valuable gasoline blending component.

Phillips Petroleum Co.'s large-scale pentane isomerization unit at Borger, Tex., the oil industry's first such plant, has now proved itself a commercial success in a little more than a year's operation, producing 16,000 bbl./day of 95% isopentane from a reactor feed of 26,600 bbl./day (85% normal pentane). This present throughput represents only about 80% of available reactor capacity.

Thus the industry has firmly taken the next logical step in its quest for higher octane gasolines: Isomerizing octane numbers into readily available natural gasoline (largely C_5's, C_6's and C_7's), an otherwise excellent gasoline blending component as regards vapor pressure and burning cleanliness. Phillips' isomerization unit boosts octane number of natural gasoline's pentane fraction to a highly re-

Unfold Flowsheet





spectable 95.6 research clear (104.1 research with 3 ml. TEL).

Since *Chemical Engineering's* roundup of C_5/C_6 isomerization processes (Nov. 1956, pp. 128-130), the oil industry has been closely eyeing routes available at that time and those introduced more recently.* Now, with quickening interest in this area, oilmen have again focused attention on natural gasoline as a prime source of isomerizable pentane. Hence these processes are good news for motorists and the oil industry's producers and refiners. But chemical processors may have to reassess the possibility of higher prices for this potential raw material.

Realizing that normal pentane is one of the major components of natural gasoline which can be readily upgraded, Phillips chose Universal Oil Products' Penex process, a hydroisomerizing route using a platinum-containing catalyst. (Previously, Phillips had done some work of its own on platinum-catalyst isomerization.)

► **Yield Is Good**—Although Penex can isomerize C_5 and C_6, the Borger unit handles only C_5's. This it does at relatively low temperatures (700-900 F.) and pressures over 200 psig. These temperatures favor equilibrium concentrations of isopentane of about 60-65% by volume. Too, hydrocracking is minimized, permitting reaction with only modest heat release, virtually no hydrogen consumption and high conversion efficiencies. Phillips obtains isomerizing efficiencies of 99-100% at conversion levels above 50%.

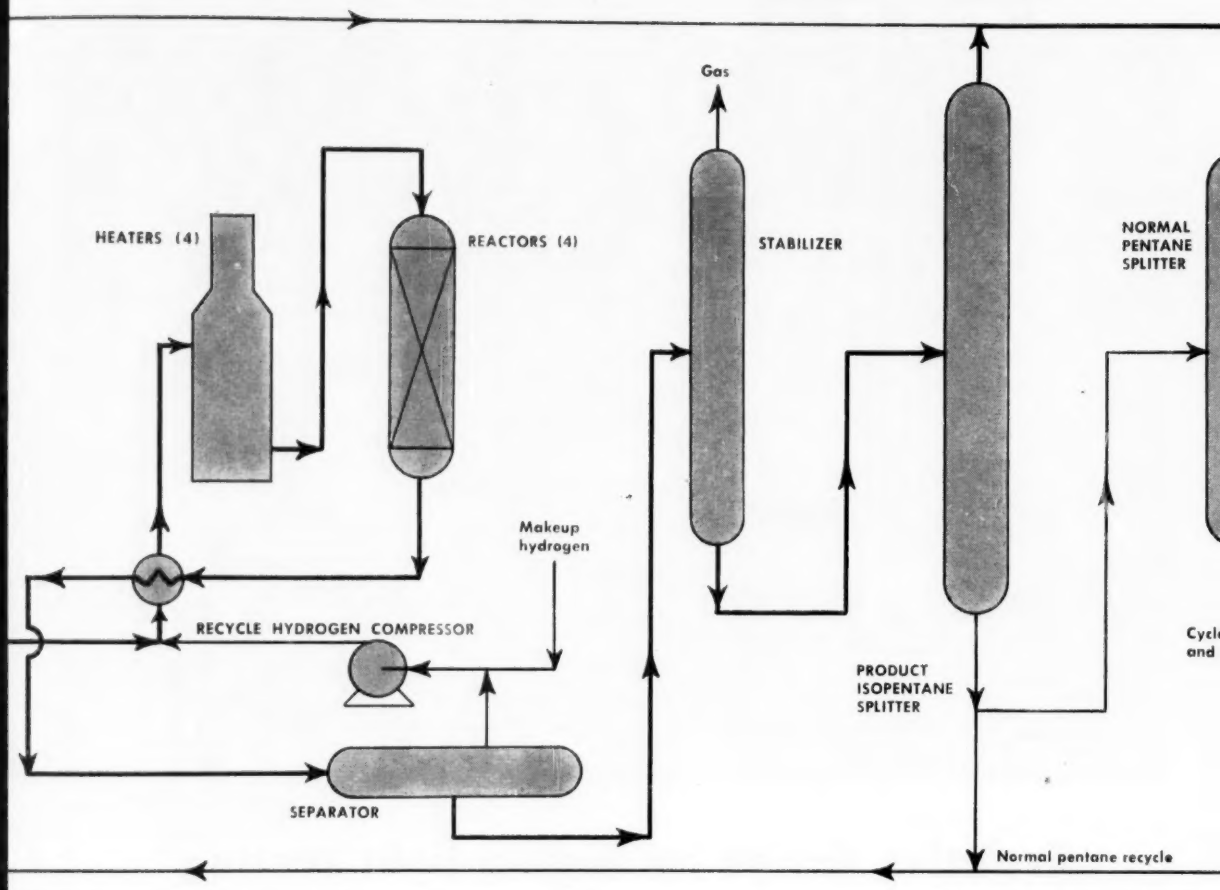
Commercial experience confirms earlier research work by UOP indicating that the more highly branched neopentane is not in the reactor product. This is worth noting, since the leaded octane number of neopentane is about seven units below that of isopentane.

UOP's catalyst, moreover, eliminates difficulties of more highly acidic isomerizing systems ($AlCl_3$, for example) by hydr
cursers. This is
nent on the catalys
gen atmosphere.
limited amounts o
► **Feed Mixes Wi**
feed is dehydrated
recycle hydrogen
catalytic reformer.
in with the feed o
reboiler. Makeup
to remove sulfur a

A centrifugal c
hp., circulates re
driving the compr
steam at 250 psig.
steam is used to r
heat feed to produ

Mixed pentanes
parallel heaters an
actor effluent pass
rator where recycl

* Most recent entry: Esso Research & Engineering, with a liquid-phase operation at low temperature, 80-120 F. Process, in development stage, was announced at recent World Petroleum Congress in New York. Another: M. W. Kellogg's vapor-phase Iso-Kel (*Chem. Eng.*, Feb. 1957, p. 142).



le) by hydrogenating sludge and coke pre-
s. This is done by a hydrogenation compo-
n the catalyst, in combination with the hydro-
tmosphere. Catalyst can also cope with
l amounts of water or sulfur contaminants.

Mixes With Hydrogen—Combined liquid
dehydrated in bauxite dryers and mixes with
hydrogen plus makeup hydrogen from a
ic reformer. Dryers remove water brought
n the feed or from leaks in the feed splitter's
r. Makeup hydrogen gets amine treatment
ove sulfur and is dried in bauxite dryers.

ntrifugal compressor, requiring about 2,000
rculates recycle hydrogen. Steam turbine
g the compressor uses superheated (450 F.)
at 250 psig. and exhausts at 50 psig. Exhaust
is used to reboil column bottoms and to pre-
ed to product splitter.

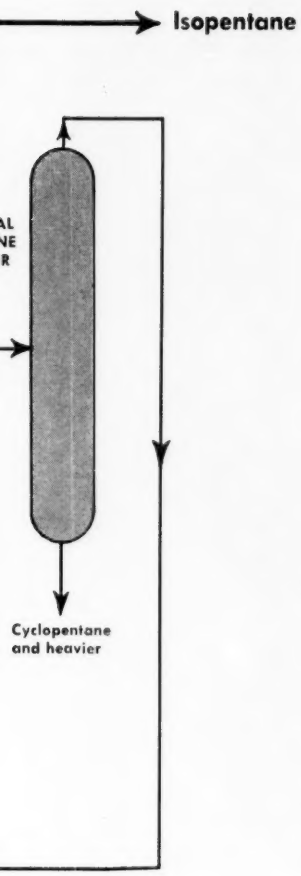
d pentanes and hydrogen then feed to four
l heaters and reactors for isomerizing. Re-
effluent passes through a high-pressure sepa-
where recycle hydrogen is removed.

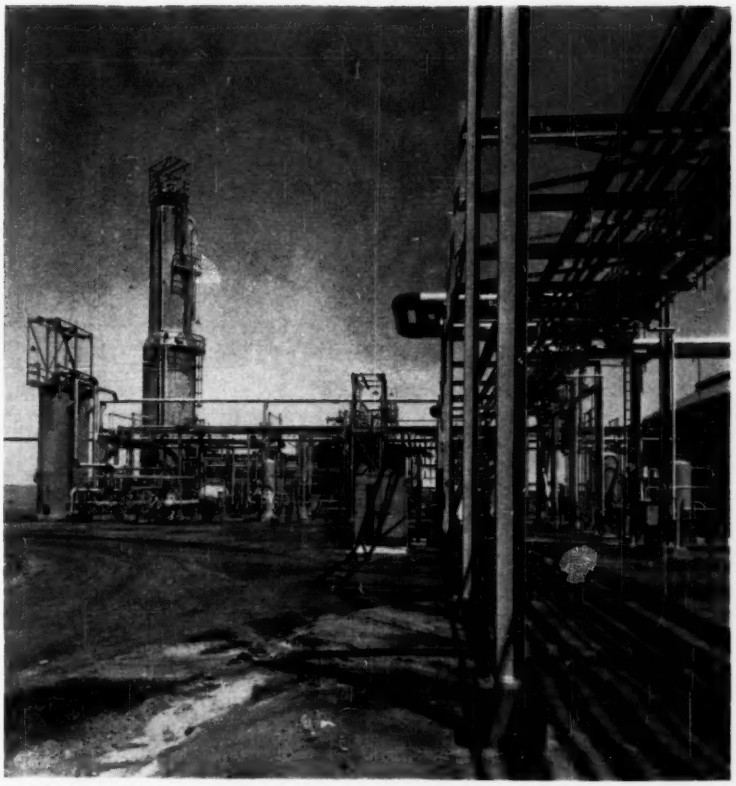
▶ **Split Product Isopentane**—Then product is stabilized in a fractionating tower to remove butanes and lower-boiling materials. Stabilizer uses four-pass trays to carry the heavy liquid load.

Stabilizer kettle product feeds to two 13-ft.-dia., 100-tray deisopentanizing towers operated in parallel. Towers produce 95% isopentane overhead and 85% normal pentane kettle product. A small tower separates the small amount of materials heavier than normal pentane to prevent these materials from building up in the unit.

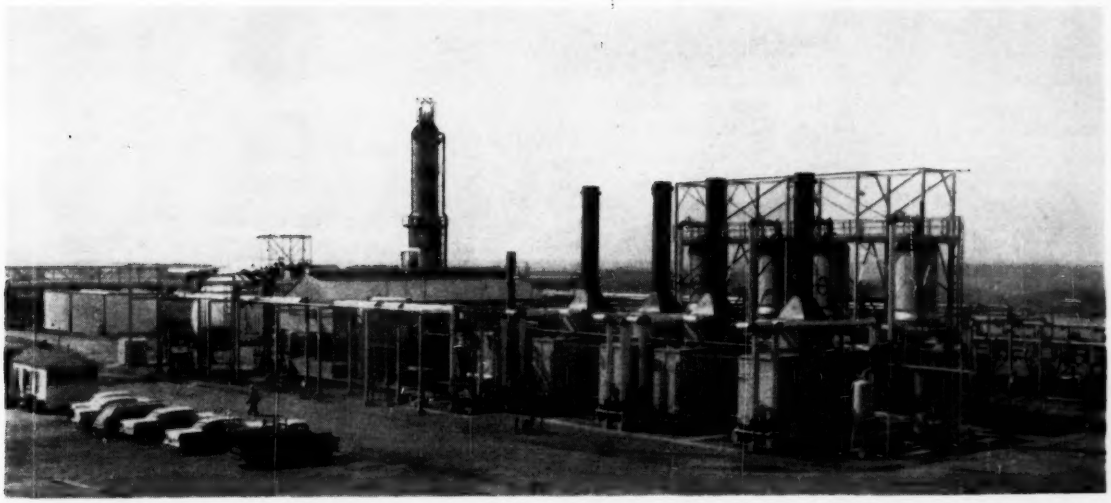
Of sidelight interest in the process is method of controlling feed ratio of hydrogen to hydrocarbon in each reactor. Temperature and flow controllers on the hydrogen recycle loop automatically provide equal volumes of identical feed to each reactor. Ratio is adjusted by changing recycle compressor speed.

A major factor in the unit's smooth startup was the use of a chromatographic analyzer to determine amounts of iso- and normal pentane in the individual reactor effluent streams.





FEED ENTERS isomerization unit at bauxite dryers (shorter towers) where water is removed and after isomerizing goes through stabilizer (tall tower).



HEATERS AND REACTORS, right foreground, are arranged in pairs, one heater-reactor pair to each of four parallel feed streams. Feed and product isopentane splitters are removed from reaction site.

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DISCHARGE PORT
DISCHARGE PORT
INLET PORT
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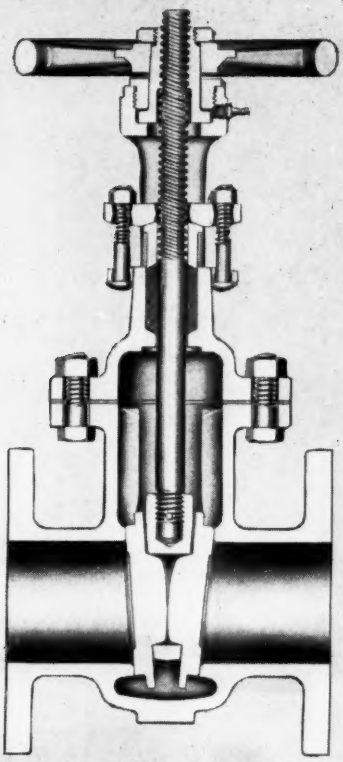
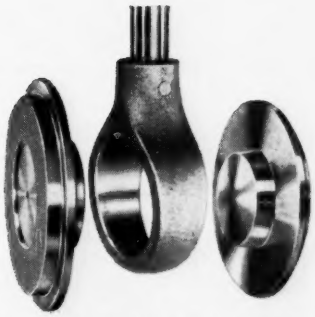
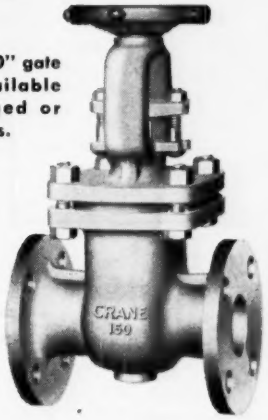


Sizes ½" to 12"; 150 psi at 500 F, 230 psi at 100 F



Crane split-wedge disc design. Identical disc halves assure uniform seating pressure.

"Craneloy 20" gate valve. Available with flanged or screwed ends.



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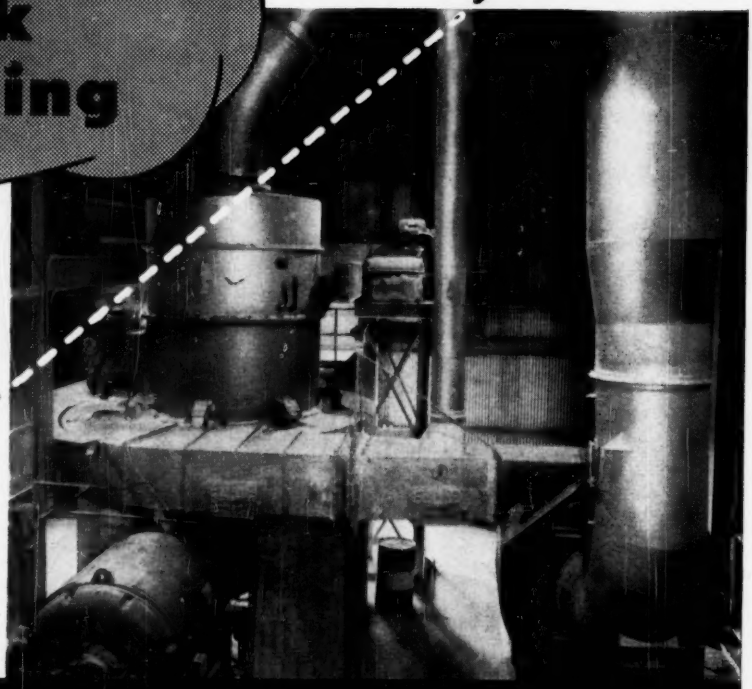
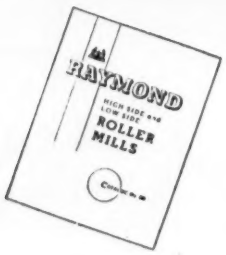


Raymond Super Roller Mill at Lake Charles Harbor and Terminal District, Lake Charles, La. — pulverizing phosphate rock.

—where Raymond Roller Mills are *FIRST*



For complete details on Roller Mills, write for Raymond Catalog No. 79.

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H Bronze eye bolt nuts
I Malleable iron gland flange
J Steel gland eye bolts
K Steel gland lug bolts and nuts
L TYPE 316 STAINLESS STEEL gland
M Teflon impregnated asbestos packing
N TYPE 316 STAINLESS STEEL bonnet bushing
O NI-RESIST CAST IRON, TYPE 2, bonnet
P Steel bonnet bolts and nuts
Q TYPE 316 STAINLESS STEEL spindle ring
R Asbestos gasket
S TYPE 316 STAINLESS STEEL wedge pin
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Chemical Engineering
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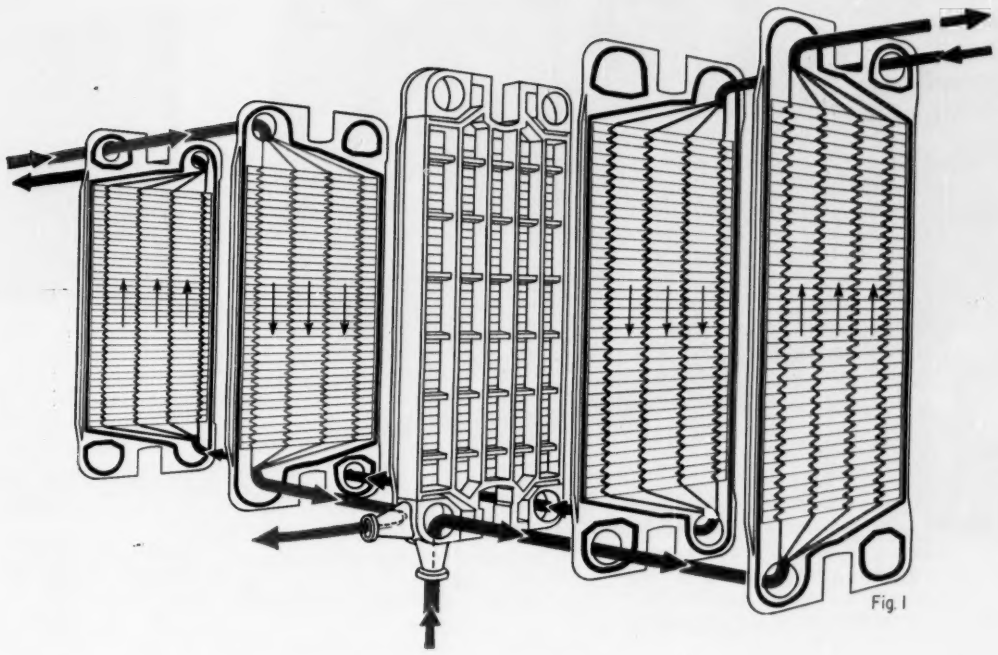


Fig. 1

Versatile, Flexible and Easy-to-Operate . . .

Plate-Type Heat Exchangers

Give Increased Heat Flux

F. J. LAWRY, The De Laval Separator Co., Poughkeepsie, N. Y.

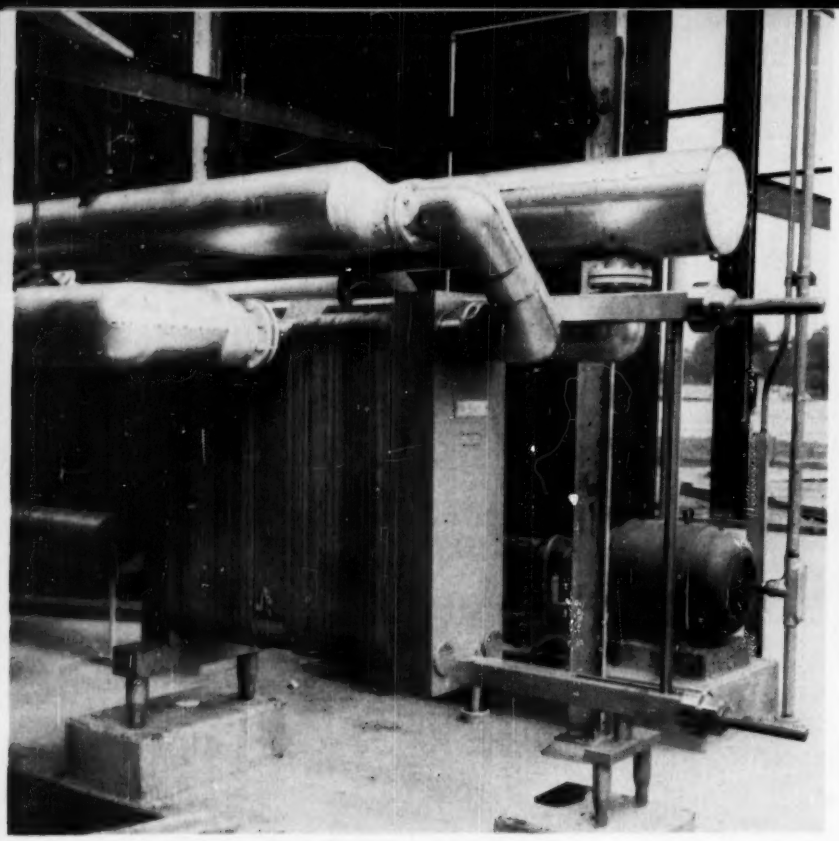
PLATE heat exchangers are similar in principle to the plate-and-frame filter press. The exchanger consists of a pack of standard plates that act as heat-transfer surfaces and a frame to support the plates. Flow of hot and cold streams alternates in the space between plates.

The earliest known patent on such an exchanger was obtained in Germany in 1878; however, it wasn't until the '30's that Bergerdorfer Eisenwerke brought out the type of plate exchanger that is the accepted design today. It features standard heat-transfer plates of a thin, narrow shape, pressed in one piece (normally from steel) with grooves to allow for rubber gaskets or packing. The plates are suspended from the top of a frame.

Plates for all makes of plate exchangers are essentially similar, differing only in fine details of design. Each manufacturer offers various plate sizes and spacings. A typical range is listed in Table I. Plate thickness, depending on manufacturer, varies from 0.05 to 0.125 in.

Plate rigidity is important because excessive deflection reduces the thickness of liquid layer between plates to a point where pressure drop is intolerable. There is a tendency to such deflection when there is a difference in hydrostatic pressure on the two sides of a plate.

Those who prefer a corrugated plate design feel that, in addition to imparting turbulence to the fluid, corrugation also adds appreciably to plate strength. Even the recessed gasket groove adds to the rigidity. Some plates have re-enforcing flanges on the longitudinal sides.



Bar Carries Plates

Compare Plate Specifications—Table I

Effective Surface, Sq. Ft.	Plate Separation, In.	Holdup Between Two Plates, Lb. of Water
1.29	0.032	0.9
3.35	0.114	3.3
5.05	0.165	5.5

Liquid flows in thin layers between plates, always in contact with heat-transfer surface. The corrugated profile of the plates causes turbulence that continuously breaks down any insulating stagnant film that tends to form on the plate surface. Corrugation also assures complete, even flow distribution.

It is turbulence that permits extremely high heat-transfer rates at comparatively low velocities. Overall heat-transfer coefficient for a typical cooling application with a plate-type exchanger is normally in the range of 600-750 and often over 900 Btu./(hr.) (sq. ft.) (°F).

Connecting the Plates

The connecting plate is used when the exchanger is set up for multiple-section applications. It provides an entrance and exit for the process fluid and the cooling or heating media. For convenience and flexibility, it is equipped with movable connections so that inlet and outlet can be spotted at any point. The connecting plate is also equipped with "through-corner" connections, if necessary, to permit a stream to pass through into the next section, where it is to be further heated or cooled.

A plate exchanger can be used for multiple duty, whether it is cooling, heating or regenerative heating and cooling. It is possible to cool two or three different liquids at the same time, or to heat a liquid in one section and cool a second liquid in another part of the same unit.

Take, for example, a problem that involves heat treating of molasses, after which the molasses is cooled. A unit might operate as follows: raw molasses enters first section (the regenerative stage) at 70 F. where it is heated to 154 F. using heat-treated product molasses for heating medium. Molasses then goes to second section where it is further heated from 154 F. to 190 F. using 5-psig. steam. After this heat treating, molasses leaves the heated side and re-enters the regenerative stage on the heating side where, in preheating the incoming feed, it cools from 190 F. to 106 F. It is possible to go to still another exchanger section where molasses is cooled from 106 F. down to 80 F. using city water at 70 F. From the city-water section, molasses might go to another section where it is cooled from 80 F. to 35 F. using 24-F. brine.

When two different products must be handled, the plate exchanger might, for instance, heat 50,000 lb./hr. of one product from 50 F. to 180 F. using steam; at the same time, another section in the same exchanger might cool 50,000 lb./hr. of the second product from 120 F. to 70 F.

Gaskets Stop Leaks

Each manufacturer uses his own rubber formulation for gasket material, but all gaskets have roughly the same operating limits—about 300 F. with operating pressures as high as about 150 psig.

Gaskets are generally inserted in a pressed depression around the plate periphery and held in place with a suitable bonding material. This protects the gasket against mechanical damage when unit is open for inspection and cleaning. It also prevents the gasket from being blown out of the plate.

Some fluids affect such physical properties as elasticity and hardness of the gasketing material. Gasket surface exposed to line fluid is therefore kept small which helps minimize gasket deterioration and, in sanitary applications, reduces possibility of contamination. In some designs, the gasket laps around the plate edge so that it serves both sides of the plate. In such an installation it is necessary to gasket only every other plate.

The plate heat exchanger frame is of simple rectangular construction, consisting of top and bottom carrying bars rigidly connected to an upright at each end (Fig. 2). Heat-transfer plates and connecting plates are suspended from the top carrying bar, which supports the entire weight of the plate pack.

In operation, a pressure plate is placed against the heat-transfer plate pack, spacer pieces are inserted on the carrying bars and the plate pack is compressed by two tightening devices. In one design, the tightener includes a thrust ball bearing and thrust washer to permit expansion and contraction, after the unit is started up, without altering the pressure on the plate pack. This eliminates overcompression, on the one hand, and leakage from undercompression or loosening of the plate pack for adjustment after start-up, on the other hand.

Most units indicate, in some fashion, the recommended compression for a specific plate pack. This information aids the operator in closing the unit and duplicating pressure in tightening the pack after inspection or cleaning.

Materials and Maintenance

Because they never come in contact with the process fluid or heat-exchange media, the frame and supporting members need not be constructed of corrosion-resistant materials. Normally, all sizes of a manufacturer's heat exchangers can be procured in either stainless steel clad construction or in enamel-coated mild steel fabrication.

For most applications, enamel finish frames are adequate. The stainless steel clad construction is best for sanitary installations, or where cleaning solutions are corrosive. Since the entire heat exchanger need not be of stainless steel, substantial savings accrue over most conventional types of exchangers that, if corrosion resistance is necessary, must be all stainless. Heat-transfer plates themselves are commonly available in Types 304 and 316 stainless as well as such materials as titanium, Hastelloy C and cupro-nickel.

The plate heat exchanger requires no special preparation for installation. Units are shipped ready for installation except for required piping connections. Most models are equipped with adjustable feet to permit immediate leveling. Since the unit is essentially vibration-free, it is not normally necessary to secure it with foundation bolts.

The plate exchanger can be cleaned in place by counter-flow circulation of cleaning solution at high velocities—normally about 1½ times product flow. In-place cleaning is effective for the same reason that heat-transfer coefficients are high—turbulent flow caused by plate design.

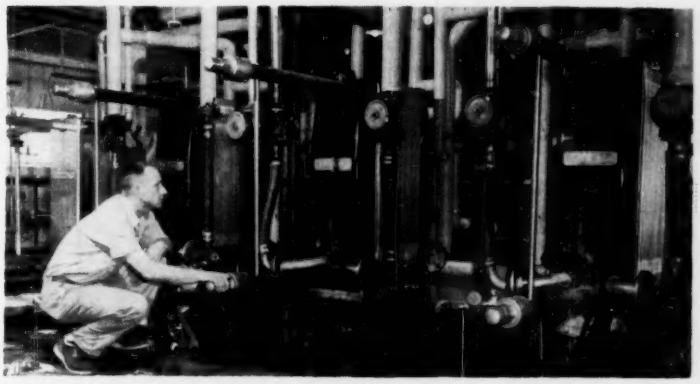
In-place cleaning should have no effect on the gasket material if, of course, proper cleaning procedure and cleaning materials are used. In most cases, dilute hot caustic solution flushed through the unit provides the necessary cleaning effect. Where necessary, a dilute solution of nitric acid is used. As soon as chemical cleaning is completed, the unit is generally flushed out with clear water. This prevents possible damage to plates or gaskets due to accumulation of cleaning compounds.

If in-place cleaning is not completely successful, at least it softens plate deposits so that mechanical cleaning is quicker. Mechanical cleaning is easy because complete, easy access to all heat-transfer surface is provided. It is necessary only to loosen two tightening nuts and roll back the pressure plate to expose the plates completely.

Plate vs. Shell-and-Tube

Under normal conditions, laminar flow exists in a smooth pipe when Reynolds number is below 2,100. Turbulent flow exists at higher Reynolds numbers. But it should

Bank of Plate Exchangers Serves Sugar Refinery



Nomenclature

a	Effective plate area.
c	Specific heat.
f_b	Correction for specific application.
f_u	Correction for u for flow velocity per plate.
f_t	Correction for u for mean temperature.
n	Number of plates.
P	Total pressure.
Δp	Pressure drop per plate.
q	Flow rate per plate.
Q	Total flow rate.
T, t	Temperatures.
t_m	Mean temperature.
Δt	Product temperature change.
Δt_m	Log-mean temperature difference.
u	Over-all heat-transfer coefficient.
U	Corrected over-all coefficient.
x	Correction for plate grouping for true counter-flow deviations.
δ	Terminal fluid temperature difference.

Sterilized Product Preheats Incoming Feed

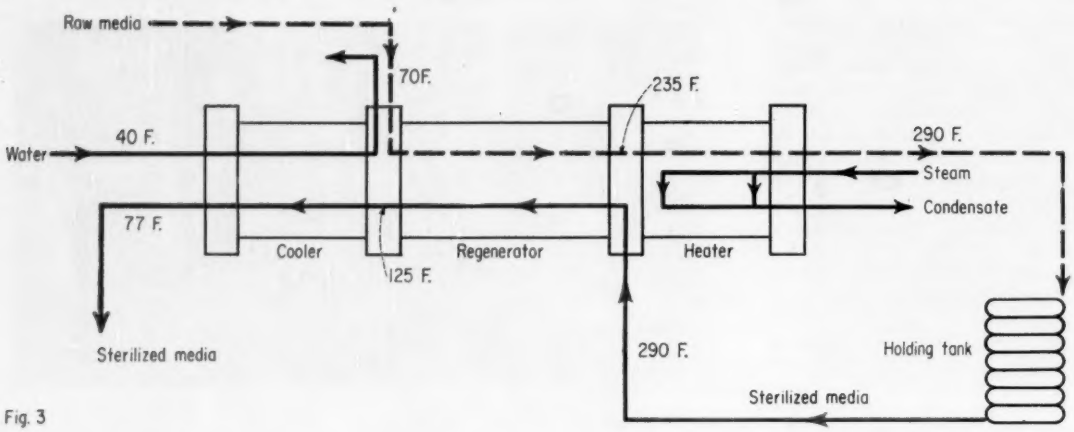


Fig. 3

be noted that these conclusions are based on experiments in smooth pipe.

As pointed out before, turbulence tends to break down the stagnant insulating film at a heat-transfer surface. It is possible to secure turbulent flow at lower Reynolds numbers if there is sufficient disturbance of the fluid flow. That's why plates almost always have a profile, such as the corrugations, that imparts maximum turbulence. Many plate-type heat exchangers secure turbulent flow at Reynolds numbers as low as 180.

Plate exchangers will always give higher heat-transfer coefficients than shell-and-tube units at the same Reynolds number. Just as important, the plate-type will have a lower pressure drop than a shell-and-tube unit with the same heat-transfer coefficient.

Table II provides a comparison of pressure drop and heat-transfer coefficients of plate and of shell-and-tube units. Heat-transfer coefficients and pressure drop may vary considerably with different plate-type exchangers, but the information given in the table is typical for equipment of many larger manufacturers.

To point up the difference in surface requirements between the two types, let's take a hypothetical heating and cooling situation. An installation requires that 33,400 lb./hr. of water be cooled from 150 F. to 70 F. using 33,400 lb./hr. of 60 F. cooling water that would be heated to about 140 F. Pressure drop should not exceed 10 psi. on either side.

The required plate-type exchanger would have an over-all heat-transfer coefficient of 430 Btu./(hr.) (sq. ft.) (°F.) and a total surface requirement of 765 sq. ft. The shell-and-tube unit would have a heat transfer coefficient of 260 and a total surface requirement of about 1,200 sq. ft. In this case, the shell-and-tube unit was figured on the basis of ¾-in.-O. D., 20-BWG tubes.

A valid cost comparison of the plate and shell-and-tube exchangers can be made only on the basis of material specification and operating requirements. If carbon steel construction is to be used, it is almost impossible for the plate exchanger to be competitive. In most cases, the plate-type will compete if the tubes in the shell-and-tube must be stainless steel. On an all-stainless steel basis, the plate-type is invariably less expensive. [The CE Cost File, p. 112 this issue, gives plate exchanger purchase cost for three materials of construction: Types 304 and 316 stainless and cupro-nickel alloy.]

There are operating conditions that override the factor of material of construction. In a multiple-duty application where both cooling and heating of one stream is required, the plate-type has decided advantage. In a plate exchanger all that is needed is a connecting plate to separate the plate packs; two shell-and-tube exchangers would be needed.

Cost advantage of the plate-type is even greater in a case where the function for which the exchanger was designed is changed and additional surface is required. Heat-transfer surface can be increased in the plate unit by adding more plates. With conventional exchangers more units would have to be added. Upper limit for expansion of one of the typical standard plate exchangers now available is 1,600 sq. ft. of heat-transfer surface, the transfer surface being 180 in. long, 33 in. wide and 73 in. high.

Compare Coefficients and Pressure Drops—Table II

Exchanger	Velocity, Ft./Sec.	Δ P, Psi./Ft.	Heat Transfer Coefficient, Btu./(Hr.)(Sq.Ft.)(°F.)
Tube (0.23 in. I.D.)	1.0	0.016	350
Tube (0.23 in. I.D.)	3.5	0.10	1,000
Plate	1.0	0.08	1,000

How-to-Do-It

Fig. 3 shows a good example of a plate-exchanger application that uses the "heat regeneration" principle. It involves the processing of various fermentation media used in the manufacture of antibiotics.

Two plate-type units are installed in a pharmaceutical plant. One unit, designed for a total capacity of 82,000 lb./hr. of fermentation media, operates as follows:

- 82,000 lb./hr. (150 gal./min.) of fermentation media are heated from 70 F. to 235 F. by the same amount of already-sterilized fermentation media supplied at 290 F.
- Media are further heated from 235 F. to 290 F. by 298-F. steam.
- Media then go from exchanger to a holding tube. They are held for sterilization for the required time at 290 F.
- Media are then cooled from 290 F. to 125 F. in regeneration described in the first step.
- Media are further cooled from 125 F. to 77 F. by 40-F. water.

The exchanger has Type 316 stainless steel heat-transfer plates and an enamel finish frame. Total installed surface is 690 sq. ft., a purchased investment of about $14,000. Price comparison with a conventional unit would have to be based on all-stainless construction since operation must be completely sterile.

An interesting sidelight is that with previous equipment it took about 15½ hr. to sterilize a batch before it went to the fermenters. Now it takes a little over three hours for the same operation.

Applications also include heating rubber latex, cooling and heating yeast cream, recovering heat from spent sulfite liquor, heating and cooling heavy chemical solutions, preheating various process feed streams and many others. Table III includes two examples.

There are, however, several limitations. Plate exchangers cannot be used at pressures in excess of 150 psi. nor at temperatures in excess of 300 F. Since the exchangers have small holdup, applications that involve condensing extremely large quantities of vapor are generally impractical. Furthermore, they can't be used for true gases. Finally, with solid-liquid suspensions, the largest particle size should not be comparable to distance between plates. Particle size should not be larger than about 0.02 in. less than the maximum distance between plates.

Plate Grouping Determines Flow Pattern

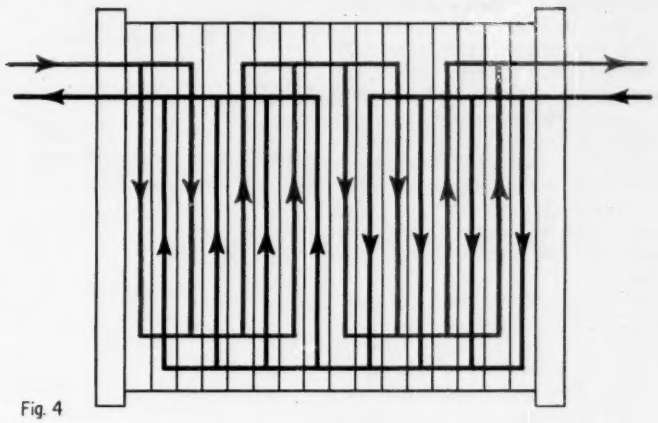


Fig. 4

Design for Plate Exchangers

"Plating" is the term used in plate heat exchanger work to designate the determination of number, type and arrangement of exchanger plates. Number of plates and location of plate ports are determined for each installation and are dependent on operating specifications. This plating flexibility is a prime reason for success of the plate exchanger in handling critical and heat-sensitive process fluids.

The designer may take advantage of product physical characteristics at different temperatures. For example, a plate grouping arrangement can be selected to maintain maximum velocity commensurate with actual fluid viscosity at any

Compare Plate Heat Exchanger Installations—Table III

Duty		
Process side	Cool 53,000 lb./hr. 18° Brix molasses from 180 F. to 90 F.	Cool 141,000 lb./hr. sulfonic acid and oil from 125 F. to 100 F.
Service side	200 gal./min. (100,000 lb./hr.) water; enter at 80 F., exit at 125 F.	141,000 lb./hr. water; enter at 72 F., exit at 83 F.
Process Material		
Sp. g.	1.08	0.94
Sp. heat	0.99	0.44
Viscosity	3 cs. @ 60 F. 2 cs. @ 90 F.	200 cs. @ 100 F. 70 cs. @ 125 F.
Exchanger*		
Δ P (process)	40 psi.	20 psi.
Δ P (service)	27 psi.	19 psi.
Surface area	268 sq. ft.	800 sq. ft.
Required space		
Length	6 ft. 5 in.	10 ft. 8 in.
Width	2 ft. 9 in.	2 ft. 9 in.
Height	6 ft. 1 in.	6 ft. 1 in.
Purchase price	$7,000	$15,500

* Material of construction for plates is 316 stainless steel.

specific point in the exchanger. This contributes maximum exchange performance and helps keep pressure drop in line.

It is common practice, especially in heaters, to reduce size of the plate groups at the end of the plate pack, or at the last pass, to increase velocity of the product at the heating medium entrance. Turbulence resulting from the increase in velocity hinders fall-out of suspended solids which might otherwise "burn-on" the heat-transfer surfaces.

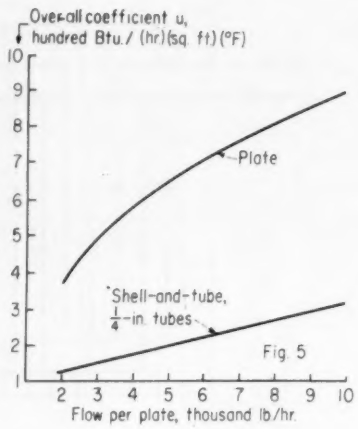
Regardless of the ratio of cooling-fluid flow to product flow (cooling-fluid ratio) used, equal velocity on hot and cold sides of the plates is maintained by regulating the size of the plate grouping. This is particularly important when pressure-drop restrictions are stringent, and it is necessary to use a large cooling-fluid ratio.

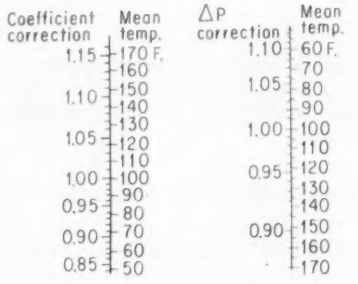
Fig. 4 is a schematic of flow pattern for an exchanger with 15 plates. Product is handled by four groups of two plates each, while cooling water is passing through two groups of four plates each. Within each group, liquid can be divided into any number of parallel flows, but each group is in series with the others. The size of each group is determined by quantity of liquid flow; number of groups is determined by the log mean temperature difference and the process fluid temperature change required.

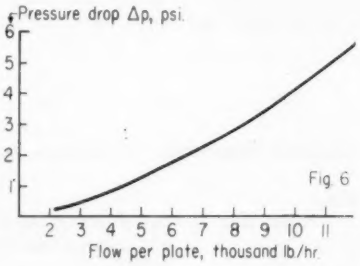
When unequal plate arrangements are used, a true countercurrent-flow arrangement is not obtained. In Fig. 4, plate arrangement departs from actual counter-flow conditions. This normally requires correction of log mean temperature difference, but most manufacturers make required corrections to the actual over-all corrected coefficient. Standard correction factors are available, for every possible plate arrangement, that account for all liquid flow ratios that might be encountered.

There is little, if any, information published or otherwise available on the actual method of calculating required surface of plate heat exchangers. For instance, there is no exact information on film coefficients and Δp vs. U correlations. Each manufacturer has developed an equation that suits his design; no one equation would apply to all makes of plate exchangers. The following example, however, is one design procedure that is used.

Charts Aid Design







Let's suppose that it is necessary to cool 40,000 lb./hr. of product from 200 F. to 80 F. by means of 80,000 lb./hr. of 70 F. cooling water.

From the statement of the problem, for countercurrent flow at entrances and exits,

Cooling water ratio = 2:1
δ_1 = 70 F.
δ_2 = 10 F.
t_m = 120 F.
Δt_m = 30.8 F.

If we assume an experimental plating arrangement,

$$\frac{\text{8,000 lb./hr. product}}{\text{8,000 lb./hr. water}} = \frac{5+5}{10}$$

then we can secure an over-all corrected value for the coefficient, using Fig. 5.

Flow/plate (per pass) = 8,000 lb./hr.
u = 800
f_t = 1.04
x = 3.5
f_b = 1.1
f_k = 0.89

$U = 800 \times 1.04 \times 0.89 \times 1.1 = 810$

We can now calculate the number of plates required.

$$n = \frac{Qc\,\Delta t}{Ua\,\Delta' t_m}$$

$$= \frac{40{,}000 \times 1.0 \times 120}{810 \times 3.35 \times 30.8}$$

$$= 57.5 \text{ plates}$$

We could, therefore, use the following plating arrangement:

$$\frac{5+5+5+5+5+5}{10+10+10}$$

This arrangement can be handled with 59 plates. The pressure drops can be calculated using Fig. 6.

ΔP = Δp × temperature correction × no. of groups
$\Delta P_p = 2.8 \times 0.955 \times 6 = 16$ psi.
$\Delta P_w = 2.8 \times 0.955 \times 3 = 8$ psi.

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Free—For your files—Check your Reader Service postcard (p. 160) for an extra copy of this article.

Now You Can Answer With Certainty. Are You . . .

Sure You Are Using the Right "K"?

$$K = y / x$$

Equilibrium Constant , K

Also known to engineers as . . .
Vaporization constant
Vaporization ratio
Volatility equilibrium distribution ratio

May have one of at least five forms,

Depending on the standard-state basis selected

$$K = P / \pi$$
$$K = f_L^\circ / f_V^\circ$$
$$K = H / \pi$$
$$K = \gamma_L P e^b / \pi, \text{ where } b = (v - B)(\pi - P)/RT$$
$$K = f_L^\circ \gamma_L' \phi_L / f_V^\circ \gamma_V' \phi_V$$

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CALCULATION of liquid-vapor equilbrium constant, *K*, is among the engineering calculations most frequently encountered in the design of chemical process plants and petroleum refineries. If vapor and liquid composition data at equilibrium are available for a particular system, then the constant can be obtained directly.

Frequently, however, such data are unavailable. They must be calculated from thermodynamic relationships or, if available, the data must be checked for thermodynamic consistency and extended to other conditions of temperature, pressure or composition.

Unfortunately, neither the definition nor the name of *K* is standardized in the chemical engineering literature. It has been referred to as the *vaporization constant, vaporization ratio, volatility equilibrium distribution ratio* and, of course, the *equilibrium constant.* Mathematical definitions have also been numerous. Depending on the conditions, *K* can be expressed by any one, and more, of the following equations:

$$K = P/\pi \quad (1)$$
$$K = f_L^\circ / f_V^\circ \quad (2)$$
$$K = H/\pi \quad (3)$$
$$K = \gamma_L P e^b/\pi \quad (4)$$

where $b = (v - B)(\pi - P)/RT$

$$K = f_L^\circ \gamma_L' \phi_L / f_V^\circ \gamma_V' \phi_V \quad (5)$$

How Combinations of Standard States Rearrange Expressions for K of Component i

	Column 1 In Terms Of Unit Fugacity	Column 2 General Form	Column 3 Ideal Solutions In Both Phases Gases Not Perfect
Case K-One—Liquid: Pure component at T and π of mixture. Vapor: Same.	$\frac{\gamma_L^S f_L^S}{\gamma_V^S f_V^S}$	$\frac{\gamma_L^S P \nu_P e^{\int_P^\pi \frac{v\,dP}{RT}}}{\gamma_V^S (\pi \nu_\pi)}$	$\frac{(1.0)\left(P\nu_P e^{\int_P^\pi \frac{v\,dP}{RT}}\right)}{(1.0)(\pi\nu_\pi)}$
Case K-Two—Liquid: Referred to infinitely dilute solution. Vapor: Pure component at T and π of mixture.	$\frac{\gamma_L^R f_L^R}{\gamma_V^S f_V^S}$	$\frac{\gamma_L^R H}{\gamma_V^S (\pi \nu_\pi)}$	$\frac{(1.0)(H)}{(1.0)(\pi\nu_\pi)} = \frac{(1.0)\left(P\nu_P e^{\int_P^\pi \frac{v\,dP}{RT}}\right)}{(1.0)(\pi\nu_\pi)}$
Case K-Three—Liquid: Pure component at T and π of mixture. Vapor: Unit fugacity.	$\frac{\gamma_L^S f_L^S}{\gamma_V^U f_V^U}$	$\frac{\gamma_L^S P \nu_P e^{\int_P^\pi \frac{v\,dP}{RT}}}{\gamma_V^U (1.0)}$	$\frac{(1.0)\left(P\nu_P e^{\int_P^\pi \frac{v\,dP}{RT}}\right)}{(\pi\nu_\pi)(1.0)}$
Case K-Four—Liquid: Referred to infinitely dilute solution. Vapor: Unit fugacity.	$\frac{\gamma_L^R f_L^R}{\gamma_V^U f_V^U}$	$\frac{\gamma_L^R H}{\gamma_V^U (1.0)}$	$\frac{(1.0)(H)}{(\pi\nu_\pi)(1.0)} = \frac{(1.0)\left(P\nu_P e^{\int_P^\pi \frac{v\,dP}{RT}}\right)}{(\pi\nu_\pi)(1.0)}$

In this article we shall adopt as our basic definition of the equilibrium constant the relationship:

$$K = y/x$$

The other forms can be derived from this.

Very often, Eqs. (1) through (5) are used without specifying clearly their limitations; the standard states; or differentiating between notation for standard state, in general, and the specific case. This can lead to serious error. To make proper use of equilibrium constants it is both very important and a necessity that engineers recognize that composition of a nonideal system plays a big part in determining the value of K.

Particularly when K-constant data were first published, charts appeared giving values of K which did not take into consideration the other components in the system, or the relative amounts in which these components were present. Because of the wide distribution of these charts—they are used even today—the importance of the effect of composition has not been fully appreciated.

The importance of the effect of composition has been well illustrated by Dodge[4] in a table of K's for methane at 160 F. and 500 psia, with various less volatile components. K varies from 3.89 to 14.6 in eight systems. Had hydrogen been a component of one of these systems, the methane K could have been even less than 1.0, emphasizing still further the error involved in disregarding the presence of other components in the system.

Most data in recent years have allowed for compositional effects through molal average boiling points[14], of one or both of the phases, by Watson characterization factors[15] or by means of activity coefficients.

It is not the purpose of this article to present a fundamental thermodynamic development of the equilibrium constant. This has been done many times in any number of texts. Rather, our purpose is to take

Column 4	Column 5
As x_i Approaches 1.0 In A Nonideal Liquid Solution; Ideal Gas Solution (Gases Not Perfect)	As x_i Approaches Zero In A Nonideal Liquid Solution; Ideal Gas Solution (Gases Not Perfect)
$\frac{(1.0)\left(P\nu_P e^{\int_P^\pi \frac{v\,dP}{RT}}\right)}{(1.0)(\pi\nu_\pi)}$	$\frac{(\gamma_L{}^S)\left(P\nu_P e^{\int_P^\pi \frac{v\,dP}{RT}}\right)}{(1.0)(\pi\nu_\pi)}$
$\frac{\gamma_L{}^R H}{(1.0)(\pi\nu_\pi)}$	$\frac{(1.0)H}{(1.0)(\pi\nu_\pi)}$
$\frac{(1.0)\left(P\nu_P e^{\int_P^\pi \frac{v\,dP}{RT}}\right)}{(\pi\nu_\pi)(1.0)}$	$\frac{(\gamma_L{}^S)\left(P\nu_P e^{\int_P^\pi \frac{v\,dP}{RT}}\right)}{(\pi\nu_\pi)(1.0)}$
$\frac{\gamma_L{}^R H}{(\pi\nu_\pi)(1.0)}$	$\frac{(1.0)\,H}{(\pi\nu_\pi)(1.0)}$

Nomenclature

a	Activity $= f/f^\circ$.
A	Van Laar constant.
B	First virial coefficient in the equation of state.
f	Fugacity, atm., psia. or mm. of Hg abs.
H	Henry's law constant.
K	Equilibrium constant $= y/x$.
p	Partial pressure of component i in the solution.
P	Vapor pressure, absolute units.
R	Universal gas constant.
T	Absolute temperature, deg. R.
v	Volume of the liquid, cu. ft./mole.
V	Volume of the vapor, cu. ft./mole.
x	Mole fraction in the liquid.
y	Mole fraction in the vapor.
Z	Compressibility factor.
γ	Equal to $\phi\gamma' =$ activity coefficient usually used $= a/x$.
γ'	Activity coefficient taking into account deviations due to molecular size and volatility.
ν	Fugacity coefficient $= f/\pi$.
π	Total pressure, absolute units.
ϕ	Activity coefficient taking into account deviations due to molecular or chemical type.

Superscripts

R	Standard state referred to infinitely dilute solution.
S	Standard state referred to the pure component at the temperature and pressure of the mixture.
U	Standard state of unit fugacity.
o	Standard state in general.

Subscripts

L	Liquid.
m	Average of values at vapor pressure and total pressure.
P	Vapor pressure.
R	Reduced conditions of P or T.
V	Vapor.
$1, 2, i$	Components.
π	Total pressure.

information available from a number of different sources and collate it, showing how the various parts are related; to take different forms of the equilibrium constant and show how they are related and used by engineers.

Starting with a general expression, we'll show how the various special forms develop logically from it, depending on the standard states being used and the particular restrictions placed on the system. By showing clearly the interrelationships among the various forms of K constants, sets of data reported by different investigators can be converted to a common basis. Also, the range of available data can be made not only larger than that of one set, but frequently even greater than their sum. Such a conversion to the common basis permits comparison of data in the same range.

In the second article of this two-part series (*to be published in an early issue*), we'll present a number of sample calculations to illustrate the application of some of the equations and to point out the advantages of using different standard states for particular situations.

Let's Start With Basic Thermodynamics

Our logical starting point is the development of basic thermodynamic relationships for

$$K = y/x$$

The definitions of activity and activity coefficient are, respectively:

$$a = f/f^\circ \tag{6}$$

and

$$\gamma = a/x \tag{7}$$

which can be combined to give:

$$\gamma = f/f^\circ x$$

or

$$f = f^\circ x \gamma \tag{8}$$

Because at equilibrium $f_V = f_L$, then by writing Eq. (8) for both liquid and vapor phases and equating the results:

$$f_V{}^\circ y \gamma_V = f_L{}^\circ x \gamma_L \quad \text{or,}$$

$$y/x = K = \gamma_L f_L^\circ / \gamma_V f_V^\circ \quad (9)$$

Here then is the basic relationship between K and the thermodynamic function from which all the special cases can be derived. Sometimes[6, 12, 21] the coefficients, γ, can be broken down into two factors, ϕ and γ'. The first takes into account deviations from ideal solutions because of molecular or chemical type; and the second, deviations due to molecular size or volatility.

When these factors are included, the expression takes the form of Eq. (5). Because of the difficulty in determining these factors separately they are usually combined into one coefficient, γ.

Eq. (9) is a general form of the equation for K. There can be, therefore, many different forms of K by changing the standard states. These different forms can be related through Eq. (8), since:

$$(f^\circ x\gamma)^{Std.\ State\ 1} = (f^\circ x\gamma)^{Std.\ State\ 2} = \text{etc.}$$

or

$$(f^\circ \gamma)^{Std.\ State\ 1} = (f^\circ \gamma)^{Std.\ State\ 2} = \text{etc.} \quad (10)$$

Of course, this relationship can be applied independently to both the vapor and liquid phases.

In the table on the preceding pages we have shown four of the more common combinations of standard states used in calculating K. They are based on combinations of three different standard states:

- Standard State 1. The pure component at the temperature and pressure of the mixture. (Designated by superscript S.)
- Standard State 2. State of unit fugacity. (Designated by superscript U.)
- Standard State 3. Standard state referred to infinitely dilute solution at the pressure of the system. (Designated by superscript R.)

We have chosen Standard States 1 and 3 for the liquid phase, while for the gas phase we have used Standard States 1 and 2 in calculating the four K's. The first column in the table shows the equilibrium constants with the appropriate symbols substituted for each of the variables.

Thus, for example, γ_L^S and γ_V^S are the activity coefficients of component i in the liquid and vapor, respectively, and f_L^S and f_V^S are the fugacities of component i in the liquid and vapor in the standard state. The superscript S indicates the specific standard state (pure component), while the subscripts L and V indicate liquid and vapor, respectively.

The next column in the table gives some of the working forms of the equation. The third column shows the form of the equation when the solutions, both liquid and vapor, are ideal but the vapors are not perfect gases. An ideal solution is defined as one which obeys the Lewis and Randall rule,

$$f_i = x_i f_i^\circ$$

over the whole range.

Columns 4 and 5 present the special forms of these equations for nonideal liquid solutions as the mole fraction of component i, x_i, approaches 1.0 (Column 4); and as x_i approaches zero (Column 5). These forms are presented to emphasize the fact that under these special conditions the activity coefficients are equal to 1.0, provided only that the standard state is chosen properly.

The horizontal entries in the table are designated as K-One, K-Two, etc., and are meant to identify only the various combinations of standard states. We do not mean to imply that they are different equilibrium constants, since in the final analysis:

$$K\text{-One} = K\text{-Two} = K\text{-Three} = K\text{-Four} = y/x$$

How to Obtain the Familiar Forms

What is the relationship among the various forms given in the table and how are some of the other familiar forms obtained? Consider, first, Case K-One in which both the liquid and vapor are referred to the pure components at the temperature and pressure of the mixture.

The fugacity of the pure component, f_L^S, is calculated by multiplying the vapor pressure, P, and the fugacity coefficient, ν_P, at P and temperature T. This represents, then, the fugacity of component i at the vapor pressure of component i and the temperature of the mixture. To correct the fugacity to the total pressure of the solution, $P\nu_P$ is then multiplied by the factor e^b where,

$$b = \int_P^\pi v\, dP/RT$$

and where π is the total pressure and v is the molal volume of the liquid.

For a liquid, v is essentially constant, giving:

$$e^{v(\pi - P)/RT}$$

The fugacity of the pure component i in the vapor phase is obtained by multiplying π by ν_π, which is the fugacity coefficient evaluated at the total pressure and temperature of the system.[12] In Column 3 of the table, of course, the only change is that the activity coefficient $\gamma_L^S = \gamma_V^S = 1.0$, because the solutions are ideal.

Since, as is well known, a solution behaves ideally with respect to component i when x_i approaches 1.0, the equations in Columns 3 and 4 are the same. Finally, in Column 5, the activity coefficient of the liquid $\neq 1.0$ since as χ_i approaches 0 the system becomes more and more nonideal with respect to component i. in the gas phase γ_V^S is shown equal to 1.0, because gaseous solutions are usually quasi-ideal, even at moderately high pressures.

The exponential term in the above expressions, which corrects the fugacity from the vapor pressure of component i to the total pressure, is usually close to 1.0 and can be neglected. At low pressures it is also usually possible to neglect the correction of pressure to fugacity so that under these conditions:

$$\nu_P = \nu_\pi = 1.0$$

Making these simplifications, we arrive at the next relationship:

$$K = y/x = \gamma_L P_L / \gamma_V \pi \quad (11)$$

Since γ_V is equal, or very close, to 1.0 when Standard State 1 is selected for the gas phase, a very familiar equation is obtained:

$$K = y/x = \gamma_L P_L / \pi \quad (12)$$

When the liquid solution is also ideal and Standard State 1 is chosen for the liquid, Raoult's and Dalton's laws are satisfactory for calculating the equilibrium constant. This gives us Eq. (1):

$$K = P/\pi \quad (1)$$

Placing pressure limitations on the application of various expressions is, of course, very difficult. How-

ever, as a guide, Robinson & Gilliland[10] have stated that this equation:

$$K = P\nu_P e^b / \pi\nu_\pi$$

where

$$b = \int_P^\pi v\, dP/RT$$

should give reasonable accuracy up to a reduced pressure of about 0.5 for mixtures which obey Raoult's law at low pressures. Therefore, we can assume that by adding the correction factor, γ_L, the equation should be equally applicable to nonideal solutions.

The pressures up to which the fugacity coefficient may be neglected can be determined by making a few quick calculations using generalized charts to determine the approximate error involved by omitting these terms.

Now, Let's Look at Case *K*-Two

For Case *K*-Two the standard state for the gas phase is the pure component at the temperature and pressure of the solution, as in Case *K*-One. However, Standard State 3 was selected for the liquid.

In the table, you can see that in Columns 2-5 the fugacity of component i referred to infinite dilution has been replaced by the Henry's law constant, which can be determined by experiment.[10, 15] This constant can be considered to be the fugacity of some hypothetical substance which behaves according to Henry's law with the other component of the mixture from $x_i = 0$ to $x_i = 1.0$.

In practice, H can be obtained by extrapolating the tangent of a curve plotted as p or f vs. x_i for very small values of x_i, to the point where the tangent intersects the ordinate at $x_i = 1.0$. The value of p or f (whichever applies at the pressure being considered) read off here is equal to H.

You will find in Column 3 this equality:

$$\frac{(1.0)(H)}{(1.0)(\pi\nu_\pi)} = \frac{(1.0)(P\nu_P e^b)}{(1.0)(\pi\nu_\pi)}$$

where

$$b = \int_P^\pi v\, dP/RT$$

which can be obtained directly from Eq. (10):

$$\frac{\gamma_L{}^R f_L{}^R}{\gamma_V{}^S f_V{}^S} = \frac{(1.0)(H)}{(1.0)(\pi\nu_\pi)} = \frac{\gamma_L{}^S f_L{}^S}{\gamma_V{}^S f_V{}^S} = \frac{(1.0)(P\nu_P e^b)}{(1.0)(\pi\nu_\pi)} \qquad (13)$$

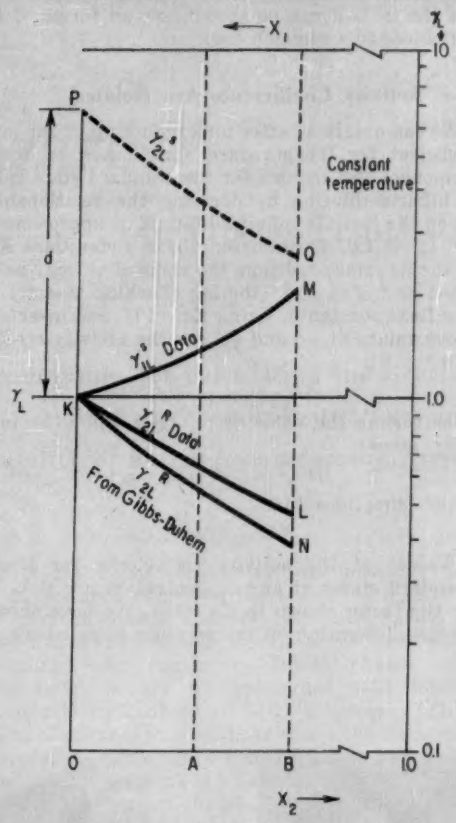
where b is as given above.

We have presented Eq. (13) to bring out two points. First, when the system is ideal, and in this case both liquid and vapor are assumed to be ideal, the activity coefficients for Standard States 1 and 3 are both unity. This is true because in the ideal system p or f_i is a linear function of x_i and Henry's and Raoult's laws become identical. Secondly, by comparing the four expressions in Column 3 it illustrates how, in the final analysis, regardless of the form or standard state chosen, the equations must reduce to a common form for any given set of conditions.

Certainly, this is not a startling conclusion; but apparently it is a source of concern to some who find themselves working with different standard states.

In Column 5 of the table, where the concentration of component i approaches zero, $\gamma_L{}^R = 1.0$ as a result of the definition of this standard state. However, we have shown above that $\gamma_L{}^R \neq 1.0$ for this condition.

How Standard States Change Gamma



On the other hand, in Column 4 $\gamma_L{}^B \neq 1.0$ for the conditions of x_i approaching 1.0, while $\gamma_L{}^S = 1.0$.

A Look at Cases *K*-Three and *K*-Four

Up to this point we have made use of two of the three selected standard states. There remains now the standard state of unit fugacity which is shown combined with Standard States 1 and 3 as Cases *K*-Three and *K*-Four, respectively.

In both cases the vapor standard state is taken as that of unit fugacity and in Column 2 of the table $f_V{}^U$ is shown as equal to 1.0. For the standard state of unit fugacity and for an ideal gaseous solution, the activity coefficient is not equal to 1.0, but rather to $\pi\nu_\pi$. We can show this by using Eq. (10):

$$(\gamma^o f)^{Std.\ State\ 1} = (\gamma^o f)^{Std.\ State\ 2}$$

or

$$(1.0)(f_V{}^S) = \gamma_V{}^U(1.0)$$

Therefore,

$$\gamma_V{}^U = f_V{}^S = \pi\nu_\pi \qquad (14)$$

Thus, even for an ideal solution the activity coefficient is not necessarily unity. Again, through Column 3 of the table it can be shown how all forms of K can be reduced to a common one.

How Activity Coefficients Are Related

We can obtain a better understanding of the activity coefficient for the standard state based on the pure component and the one for the standard state referred to infinite dilution by deriving the relationship between the two. At infinite dilution, x_i approaches zero, and λ_L^R is 1.0, as discussed above under Case K-Two.

At this same condition, the value of γ_L^S may be designated as $(\gamma_L^S)_{inf.\ dil.}$ (the log of which is equal to the Van Laar constant). Using Eq. (10), and inserting the above values of γ_L^S and γ_L^R for the activity coefficients at $x_i = 0$:

$$f_L^S(\gamma_L^S)_{inf.\ dil.} = f_L^R(1.0) \qquad (15)$$

Substituting the value of f_L^R from Eq. (15) into Eq. (10) gives:

$$f_L^S\gamma_L^S = [f_L^S(\gamma_L^S)_{inf.\ dil.}]\gamma_L^R$$

which simplifies to:

$$\gamma_L^R = \gamma_L^S/(\gamma_L^S)_{inf.\ dil.} \qquad (16)$$

Values of the activity coefficients for these two standard states at any concentration are thus related by the factor shown in Eq. (16). We have shown this in the illustration on the previous page where γ_L^S and λ_L^R, shown respectively as lines PQ and KL, are separated by a constant distance, d, equal to:

$$\log (\gamma_L^S)_{inf.\ dil.}$$

Application of Standard State 3

The fact that γ_L^S and γ_L^R are so simply related might lead to this question: Why resort to the use of γ_L^R at all? Why not just use γ_L^S?

Here's why. Inspection of the expressions for K when the pure state is selected for the standard state shows that in all cases the vapor pressure, P, is involved. When working with H_2, CH_4, CO, CO_2, N_2, etc., the temperature is nearly always so far above the critical that no vapor pressure can even be estimated by extrapolating. Selection of the standard state referred to infinite dilution avoids this difficulty.

This can be brought out more forcefully by a discussion of two frequently encountered thermodynamic calculations. Taking the expression for Case K-Two in Column 1:

$$K = \gamma_L^R f_L^R/\gamma_V^S f_V^S$$

and replacing f_V^S by πv_π results in this equation:

$$K\pi v_\pi = \gamma_L^R f_L^R \qquad (17)$$

when $\gamma_v^S = 1.0$. Eq. (17) is extremely useful when working up experimental data for:

- Extending data to other temperatures and pressures.
- Calculating heats of solution.
- Testing data for thermodynamic consistency.
- Other applications where activity coefficients are involved.

In an Early Issue: Practical Applications

In the second article of this two-part series, we'll present some worked out illustrations which will point up the practical applicability of what we have discussed so far. Look for it in an early issue.

Stanley B. Adler

Dominic F. Palazzo

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How to Calculate and Combat

Static Electricity Hazards

In Process Plants—II

Here are techniques for calculating the hazards in many chemical situations and steps to take to reduce the possibility of an explosion-causing spark.

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COSTLY shutdowns, loss of equipment, injured personnel—these are some of the penalties for overlooking electrostatic hazards in chemical plants. This is a real and little-appreciated problem.

We know fairly well the mechanisms behind electrostatic accumulation: voltages can build up to high figures in a flowing system of a nonconducting liquid causing a high-energy spark; vapors, mists and dusts can be easily exploded with minimum ignition energies of 0.1, 1 and 10 mj. respectively (see *Chem. Eng.*, June 1, 1959, pp. 99-102).

But it is also possible to calculate and get a rough measure of static electricity hazards for many operational situations in the chemical industry.

However, before getting into the calculations, we need to know something about the electrical properties of organic chemicals.

Liquids Present Serious Hazards

Many people make a serious error when considering liquids. This is in only being concerned about liquids whose vapor pressures at ambient temperatures could give vapor-air mixtures above the liquid within the explosive concentration limits. However, the explosibility of liquid mists tends to blur any lower limit based on volatility (see *Chem. Eng.*, June 1, 1959, p. 102). Transient mixing and blending (such as tank breathing) can render many "safe" liquids hazardous. Thus, a preliminary screening on the basis of vapor pressure can be very misleading.

Fig. 1 broadly categorizes organic chemicals as to electrostatic hazards by their dielectric constant and electrical conductivity.[5, 6]

At this point, some definitions are in order. Dielectric constant is the specific inductive capacity of a material. It is equal to the ratio of capacitance of two condensers of equal size—one using the particular dielectric, the other using vacuum as the dielectric. Of course, capacitance expresses the ability of a circuit to hold or store electric charges. The unit, farad, is the capacitance which will store one coulomb/volt.

In dealing with continuous liquid phases and grounded walls, we are only concerned with liquids whose conductivity is about 10^{-11}-10^{-18} mho/cm.[23] (This limitation, of course, does not hold where the walls are not grounded). For specific conductivities less than 10^{-18} there will, in general, not be enough charged particles present to form an electrical double layer at the phase boundary—without this there can be no electrokinetic phenomenon (i.e., streaming current or flow of electricity caused by entrainment of charges by a flowing liquid).[4, 7]

From Fig. 1 it may be seen that at least from available figures, hydrocarbons and ethers seem to be the only classes of liquid organic chemicals which have electrical conductivities low enough to present a hazard in continuous flow situations into grounded vessels.

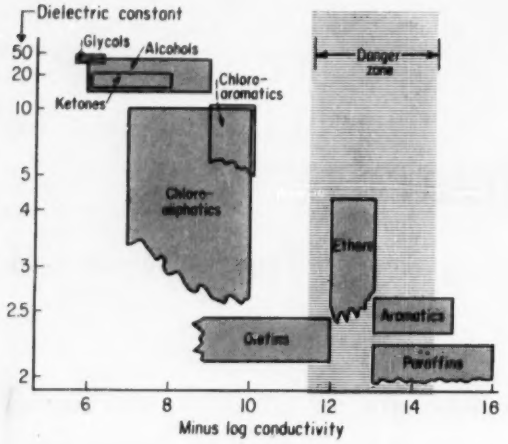
Importance of Dielectric Constant

There is a substantial correlation between conductivity and dielectric constant.

What conductivity low-conductivity liquid organics do have is primarily created by the presence of dissolved extraneous material which provides charged particles by dissociation. The decisive importance of dielectric constant of the liquid lies in its strong influence on degree of dissociation of such dissolved electrolytes. Fig. 2, taken from the work of Kraus and Fuoss,[8] shows how identical concentrations of an electrolyte dissolved in solvents of different dielectric constants can produce dramatically different levels of conductivity.

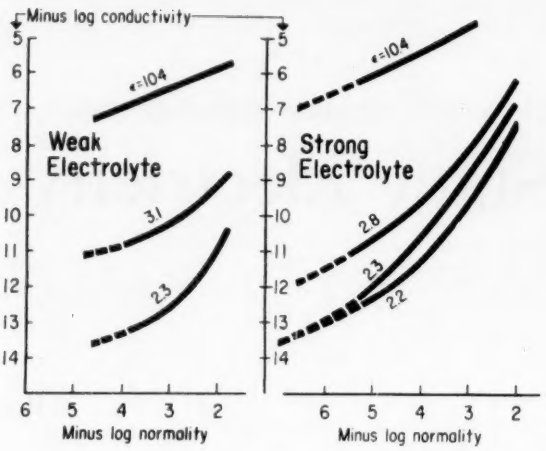
While type of dissolved material can make a substantial difference, the effect of dielectric constant is so striking that initial screening is possible on the basis of dielectric constant alone. The terms strong and weak electrolyte used in Fig. 2 refer to behavior

*This concludes a two-part series by the author on electrostatic hazards. For theory as well as author's biography, see the June 1 issue, p. 99.



Hydrocarbons: Static Electricity Hazard **Fig. 1**

In the group of liquid organic chemicals, hydrocarbons give the most trouble from static electricity. This is because electrical conductivities are very low, permitting charges to build up, particularly under conditions where a fluid flows into a grounded tank. Note that the figure above shows some correlation between conductivity and dielectric constant (*see text*).



How Dielectric Affects Conductivity **Fig. 2**

Dielectric constant—a measure of the capacity of a material to hold electric charges—has a strong effect on organic-solvent conductivity. Actually, the dielectric constant property influences the dissociation of dissolved electrolytes, carried as impurities in many hydrocarbons. The higher the constant the more dissociation and the greater the conductivity.

in aqueous solutions and can be considered only a qualitative differentiation in the nonaqueous solvents we are talking about.

Effect of various types of additives on hydrocarbon conductivity is further brought out in Fig. 3. Scattered data[6, 8, 7] have been collected here and corrected to a hypothetical medium with a dielectric constant of 2.2, by correcting conductivity values on the basis of the approximate relationship that a 0.1 increase in dielectric constant will increase electrical conductivity by roughly 50%.[6, 8]

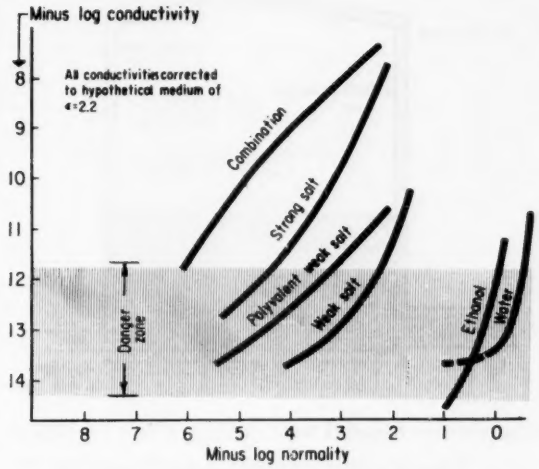
Nomenclature

A	Pipe cross-section, sq. cm.
C	Capacitance, farad $= \epsilon\epsilon_0\rho/R$.
I	Current, amp.
L	Pipe length, cm.
Q	Electrostatic charge, coulomb.
R	Electrical resistance, ohm.
V	Voltage, volt.
W	Energy of an electrical discharge, joule.
ϵ	Dielectric constant (dimensionless ratio).
ϵ_0	Absolute dielectric constant of a vacuum $= 8.85 \times 10^{-14}$ sec./ohm-cm.
ζ	Contact potential, volt.
κ	Electrical conductivity, mho/cm.
μ	Viscosity, poise.
μf	Microfarad.
ρ	Electrical resistivity, ohm-cm.
τ	RC = relaxation time constant, sec.

A strong electrolyte will require a concentration of about 10^{-4} normal to provide sufficient conductivity to be safe while a weak electrolyte would require 100 times that concentration. Note that very weakly ionic additives such as ethanol or water require much higher concentrations to affect conductivity appreciably. Whatever effect water or alcohols may have as solutes in hydrocarbon solvents is primarily in increasing the dielectric constant.

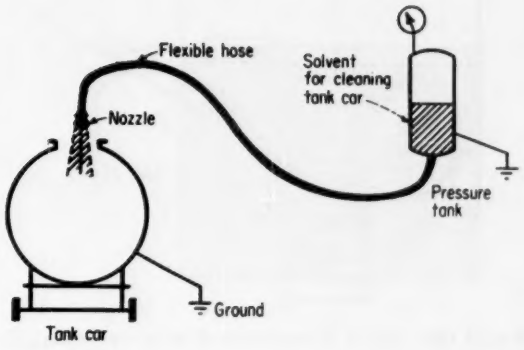
A distinctive contribution in this field has been made by Klinkenberg, et al, who found that by using certain combinations of polyvalent electrolytes a considerable enhancement in electrical conductivity could be obtained at rather small concentrations.[5, 4] The synergistic effect is believed due to the possibility of forming a number of different ion-molecule association complexes, giving a much stronger dissociation than would be the case, were each salt present alone. A level of only a few parts per million of such combination additives is sufficient to bring the conductivity of even very pure hydrocarbon streams up to the level of 10^{-11} mho/cm.

It should be noted that there are cases where two solutes may somewhat cancel each other and produce a lower electrical conductivity than either one alone would. It is also a common observation that an additive may actually reverse the sign of the charge from that observed previously. It will bear repeating that we are not too much concerned here with the sign of the deposited charge, although it could conceivably make some slight difference in certain geometric situa-



Additives Up Hydrocarbon Conductivity **Fig. 3**

As the figure above shows, additives to hydrocarbons can radically change conductivity. A strong salt will require a concentration of about 10^{-4} normal for a safe conductivity, a weak salt will call for 100 times this concentration. Note that weak electrolytes such as ethanol and water require very high concentrations before hydrocarbon conductivity is out of the danger zone.



Avoid Ungrounded Spray Nozzle **Fig. 4**

A seemingly simple operation can result in a serious situation, as above. Here an organic solvent flows through a flexible hose to rinse out a tank car via air pressure. Tank car is grounded, the hose nozzle is not. Charges build up on the nozzle —a voltage of 2,000 v. would not be unusual. This is enough to cause a spark, setting off the solvent fumes in the tank car.

tions (since the spark originates from that side of the gap which has a surplus of electrons).

The above, of course, refers to additives which are miscible with the liquid. If a second, more conductive, liquid phase is present as a dispersed phase, electrokinetic phenomena will in general be considerably enhanced. For example, introducing a small quantity of aqueous phase into a rapidly flowing hydrocarbon stream in a plant-scale pumping test increased the electrostatic field strength in the receiving tank by a factor of 10-to-50-fold.[4]

Addition of a gas phase can also have a very strong effect but only at an appreciable volumetric concentration in the flowing stream. The effect here is probably one of increased turbulence and/or the creation of a flow system which involves suspension of liquid droplets in gas.

Two-phase flow is particularly hazardous. Peak voltage is not necessarily reached at the point when flow ceases but frequently sometime later, as the droplets of conductive phase settle out in the receiving tank.

Examples of Fluid Hazards

Let us set off the above discussion of low-conductivity liquids with three illustrative examples, embracing more-or-less stock situations, where an electrostatic hazard exists even though the electrical conductivity of the flowing stream is what we would have called high enough to be safe, from our above discussion.

It would be useful to remember that the energy stored in a charged condenser is:

$$W = 0.5CV^2$$

and since $C = Q/V$:

$$W = QV/2 = Q^2/2C$$

Also, the electrical conductivity κ, is also known as specific conductivity. The reciprocal of this is called specific resistivity, ohm-cm. ($R = L/A\kappa$).

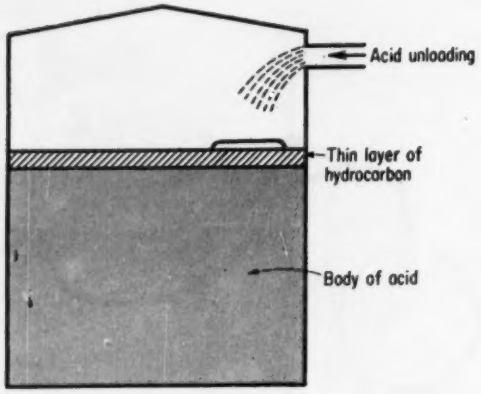
Fig. 4 shows a common situation where an organic chemical solvent with a specific conductivity of around 10^{-8} mho/cm. is pressured through a flexible hose to rinse out a tank car compartment.

The tank car is grounded; but hose nozzle is not grounded. Calculations are as follows:

$R = 10^8$ ohm-cm. $\times$ 400 cm./20 cm.^{2} $= 2 \times 10^9$ ohm
$I = 10^{-7}$ amp./gpm. $\times$ 10 gpm. $= 10^{-6}$ amp.
$V = IR = 2{,}000$ v.
$C = 50 \times 10^{-12}$ farad
$W = 0.5\,CV^2 = 0.1$ mj.

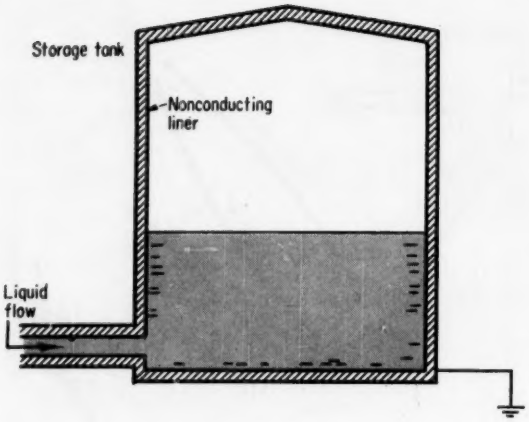
Voltage built up on the nozzle with respect to ground is determined by the resistance back to ground through the flowing solvent itself, which in turn depends upon the hose dimensions. It is calculated as roughly 2 x 10^9 ohm. Assuming a moderately high streaming current of 10^{-7} amp./gpm. and a flow rate of 10 gpm. through the nozzle, with charges arriving at the nozzle at the rate of 10^{-6} amp., steady-state voltage on the nozzle will therefore be of the order of 2,000 v. If the nozzle is held close enough to the top hatch of the tank car, this voltage will cause a spark to jump.

Lastly, it is necessary to check whether such a spark



Watch Out When Transferring Acid **Fig. 5**

Compressed air is frequently used to transfer acid into a storage tank. Electrical discharge can occur at the end of the cycle when air blows through. Key to this situation: a thin layer of low-conductivity hydrocarbon on the acid. Acid droplets collect on this layer. Voltage across the "sandwich" can be around 10^4 v. The spark can set off a combustible atmosphere.



Dangerous: Lined Tanks **Fig. 6**

When a tank is lined with a plastic material, the vessel can act as a huge electrical capacitor, as above. Here a liquid flows into the tank, bringing electrical charges with it and voltages can build up to very high figures across the tank wall. A spark results when a grounded object is placed near the liquid surface. Fortunately, minute flaws in the lining reduce the danger somewhat.

might be strong enough to initiate an explosion. This can be done by estimating the capacitance between the nozzle and tank car as being a maximum of 50 x 10^{-12} farads. This yields a possible energy of 0.1 mj. for the spark which may result, just borderline on hazard.

In the incident from which this example was taken a certain amount of air was trapped in the hose so there was, for some seconds at least, a two-phase flow situation, which presumably aggravated the resultant spark. Even had the nozzle been grounded there would be some sort of electrical discharge associated with the impinging of the solvent droplets on the inside of the grounded tank car. However, without the services of the nozzle as a charge-collecting medium, the energy of the sparks from individual droplets would probably not be great enough to be hazardous.

Unloading Acid Into Tanks

Another situation which merits special emphasis because of its frequency is unloading acid into tanks through overhead lines. The presumed mechanism of discharge and some quantitative aspects are shown in Fig. 5.

Acid transfers are frequently made using compressed air and the electrical discharge usually occurs at the end of the transfer, when the air is blowing through. Typically, such tanks have a thin skim layer of heavy hydrocarbon floating on top of the main acid layer. This skim layer may have a surprisingly low electrical conductivity. The mechanism we have supposed here is the transient collection of a number of acid droplets as an agglomerate temporarily floating on top of the skim layer and therefore making a small "sandwich" which functions as an electrical capacitor whose dielectric is the hydrocarbon layer.

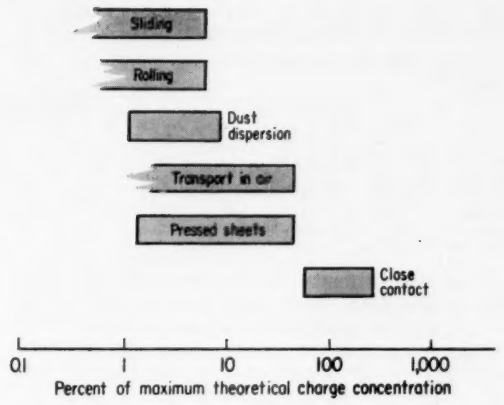
If the acid pool amounts to only 0.001 gal., containing charge at 10^{-8} coul./gal. (which is not unreasonable for the two-phase flow situation), then the charge accumulation in the pool is 10^{-8} coul. And the capacitance of such a pool, perhaps only 2 in. in diameter, might be of the order of 10^{-12} farads to ground; that is, to the main acid layer. The voltage across the sandwich is therefore calculated at 10^4 v.

$$Q = 10^{-6} \text{ coul./gal.} \times 10^{-3} \text{ gal.} = 10^{-8} \text{ coul.}$$
$$C = 10^{-12} \text{ farad}$$
$$V = Q/C = 10^4 \text{ v.}$$
$$W = 0.5\,Q^2/C = 0.05 \text{ mj.}$$
$$R = 10^9 \text{ ohm}$$
$$RC = 10^{-3} \text{ sec.}$$

As the unstable arrangement is terminated and the small acid pool joins the main layer, a spark discharge will occur, here calculated as being of the strength of 0.05 mj. While this is just below the hazardous energy range, it does not give the order-of-magnitude safety margin which is desirable in such situations. A subsidiary calculation estimates the *RC** time constant of the sandwich as 0.001 sec. Charge buildup and discharge is therefore quite conceivable within the probable lifetime of our hypothetical acid pool.

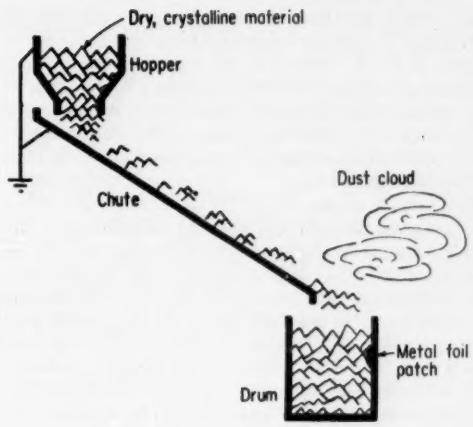
The acid unloading example, besides occuring in an electrically conducting situation which might not ordinarily be suspected as hazardous, also illustrates the potential dangers in presuming the absence of an explosive atmosphere. In a case where the supernatant hydrocarbon layer was not volatile enough to provide

*Has units of time, and gives a measure of time necessary to reach steady state voltage, or time required for charges to leak off after the streaming current has stopped.



Contact of Solids Builds Up Charge **Fig. 7**

For solids, close contact can be more effective in generating electrostatic charges than frictional impact. Mild contact—particles sliding down a metal chute—build up lower quantities of charges, while pressing plastic sheets together can result in sizeable concentrations. However, charge build up from solids is also a function of contact time and bulk conductivity of the particles.



Avoid a Charge Collector **Fig. 8**

As shown above, dry material from a hopper goes down a chute into a drum. The particles pick up electric charges sliding down the chute, and also create a dust cloud. You must have a charge collector in the drum before this situation can get serious. This is the metal foil patch which attracts electric charges. A spark from this patch can ignite the dust cloud.

an explosive atmosphere, and where noncondensable combustibles were apparently thoroughly stripped from incoming acid, careful measurements revealed that the atmosphere in the tank was in the explosive range occasionally, either from corrosion or some unestablished source.

Watch Out for Nonconducting Liner

Some problems arise in the situation of pumping into a tank with a nonconducting liner.

While we know of no incidents stemming from the use of nonconducting liners, their increasing use in corrosive and other services makes them worthy of consideration. They provide a useful example of how to calculate in the case of an insulating container.

Assume liquid conductance is relatively high compared with that of the tank wall, but not so high that the tank contents can be considered grounded through the entry line. The charges introduced into the tank by flow at an assumed rate of 100 gpm. will accumulate close to the tank walls rather than be concentrated near the center of the tank as in the case of a nonconducting liquid with grounded walls. In other words, the nonconducting liner functions as the dielectric of a huge electrical capacitor. For the dimensions and electrical properties of the tank shown in Fig. 6 (liner thickness: 10 mils; liner electrical resistivity: 10^{14} ohm-cm.; wetted area: 300 sq. ft.; dielectric constant: 5) we calculate that resistance to ground across the liner is of the order of 10^{7} ohms, the capacitance about 4 microfarads. The streaming current will be rather high for the 100 gpm. flow, because we are speaking about a polar solvent with a dielectric constant an order of magnitude higher than that of a hydrocarbon.[7]

The steady-state voltage buildup across the liner is of the order of 100 v., not enough to cause sparking even if a grounded object were inserted near the liquid surface inside the tank:

$$R = 10^{7} \text{ ohm}$$
$$I = 10^{-7} \text{ amp./gpm.} \times 100 \text{ gpm.} = 10^{-5} \text{ amp.}$$
$$V = IR = 100 \text{ v.}$$
$$W = 0.5\ CV^{2} = 20 \text{ mj.}$$

If the specific electrical resistivity of the liner had been an order of magnitude higher, voltage would be high enough to be hazardous and a very high energy spark might result because of the high capacitance of this system. For the same reason, such systems have high RC time constants, so that any actual hazard may persist for some minutes after the cessation of flow. One comforting element in the situation is that minute flaws generally render the resistance of thin linings at least an order of magnitude lower than would be calculated from their thickness and bulk resistivity. Absorption effects, which depend on the nature of the contained liquid, can significantly alter the conductivity of linings.

Electrostatic Properties of Solids

Now let's consider the problem of handling solids. When the surfaces of a metal and an insulator come sufficiently close together (on the order of 10^{-8} cm.), charge transfer will take place. Equilibrium is rapidly reached in which the energy levels in the adjacent solids have been equalized.

In the subsequent separation of the two surfaces, voltage gradients at the surfaces will be large enough

to cause corona discharges until the average charge concentration on the surfaces has been reduced to the theoretical level of above 3×10^{-9} coul./sq. cm.

In transient contact between metals and insulators, such as occurs when granular solids slide along metal surfaces, only very small portions of the particle surface ever come in close enough juxtaposition to permit charge equilibration.

Small changes in the impurity level in the surface of the particles can change the magnitude and even the sign of the resulting charge. The observations of Thomas[1] on coal dust sliding down metal chutes provide an interesting illustration of the effect of changes in the nature of the surface upon the charging phenomenon. He initially exposed coal particles to mild oxidation for varying periods. Although oxidation actually reverses the observed sign, the magnitude of the charge on the strongly oxidized surface is not very different from the original charge.

Extent of electrical charging in solid contact can be related to closeness of contact.

Fig. 7 compares the results of various investigators of static electrification of solids. The charge density per unit surface which was observed, expressed as a percent of the theoretical maximum charge density (beyond which corona discharge to the atmosphere would occur upon separation of the surfaces), is plotted for the various contact mechanisms involved.

Close contact, whether by pressure or by close machining of the surfaces, was if anything more effective in generating electrostatic charge than frictional contact. This reinforces the idea that so-called "frictional electrification" is primarily just one means of securing the necessary close contact of surfaces for change transfer to occur. The milder forms of contact such as sliding or rolling of particles down a metal chute or dust dispersion in air are seen to produce charge concentrations only about 10% of the theoretical maximum. Charge obtained in these transient contacts[2] is a function of contact time and also of the bulk conductivity of the moving particles. Furthermore, reproducibility of measurement in this field is notoriously difficult, requiring extreme precautions in experimental technique. The order-of-magnitude figures, 10% and 100% (3×10^{-10} and 3×10^{-9} coul./sq. cm.) of theoretical, for casual and close contact situations respectively, will suffice for our present needs.

Drum Loading of Crystals

Let us see, in Fig. 8, how we can apply these considerations in an actual instance.

Dry crystalline material discharged from a hopper passes down a chute and into a product drum. Electrification of the particles occurs in sliding down the chute and it is assumed that enough fine particles are dispersed into the air about the drum to provide a dust cloud which is a suitable medium for combustion.

Discharges from individual particles will not be nearly strong enough to initiate combustion. An ungrounded conductive surface must be present to serve as a collector for the charges from the individual particles, in a position where they may jointly be discharged in a spark of appreciable strength. In Fig. 8, we have visualized this collector as a metal foil patch on the surface of the cardboard drum. The metal foil need not be in physical contact with the heap of crystals inside the drum. A portion of the charge on the crystals resting in the drum will, nevertheless, in effect be transferred to the metal by induction. Calculations are:

At the drum,
$R = 10^9$ ohm
$C = 10^{-10}$ farad
$RC = 0.1$ sec.

$I = 2 \times 10^{-10}$ coul./cm.$^2 \times 50$ cm.^{2}/g. $\times 2{,}000$ g./sec. $= 2 \times 10^{-5}$ amp.
Q (crystals) $= I \times RC = 2 \times 10^{-6}$ coul.
Q (foil) $= 10^{-7}$ coul. C (foil) $= 10^{-11}$ farads
$W = 0.5\, Q^2/C = 0.5$ mj.

Here we have estimated the RC time constant, from the top of the heap of crystals down to ground potential beneath the drum, as being in the order of 0.1 sec. This means that the fresh charges arriving with material falling off the chute are draining off very rapidly to ground. Knowing the weight rate of discharge of crystals, the surface/weight ratio of these crystals, and assuming that the charge density per unit surface is close to 10% of theoretical maximum, we arrive at the reasonable estimate of 2×10^{-5} amp. as the rate of charge arrival.

The product of current and the RC time constant of the heap of crystals gives us a measure of the instantaneous amount of charge in the drum at steady-state conditions. By assuming that the foil patch intercepts 5% of the electrical lines of force from the charge within the drum, we are able to estimate the charge transfer to the foil by induction as 10^{-7} coulomb. If the capacitance of the foil patch to ground is estimated as 10×10^{-12} farads, then a spark occurring from this patch to any approaching grounded object can be estimated from the usual formula as $\frac{1}{2}$ mj., not nearly sufficient to ignite a dust cloud. Had the flow down the chute been faster, or the effective bulk resistivity of the crystals in the drum higher, we would indeed have had a hazard to reckon with.

In conclusion, a number of methods are available for reducing accumulations, after you have determined that a hazard exists. These include: reduce leakage resistance to ground by increasing liquid conductivity, by grounding conductive material, and by humidity control; also you can alter the geometry by a "relaxation" section of pipe which gives charges time to drain off, or avoid free fall of liquids or provide a floating roof on tanks to avoid explosive concentrations; and you can reduce charge generation by lowering flow rates, by avoiding two-phase flow or by altering agitation techniques. When none of these is practical, provide a blanketing atmosphere.

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Based on a paper given at an all-day symposium, N. Y. section, A.I.Ch.E., Oct. 23, 1958.

Estimated Operating Cost of 500-Ton/Day Oxygen Plant—Table 1

Capital investment $4,450,000; 99.5% purity; 450 psig. discharge pressure

Direct Cost		
Utilities		
Power: 228,000 kwh./day × 350 × $0.0075/kwh	$598,500	
Cooling water: 3,000 gpm. × 60 × 24 × 350 × $0.015/1,000 gal	22,700	
		$621,200
Direct labor		
48 Man-hours × $2.50 × 365	$43,800	
Supervision at 15%	6,600	
		50,400
Plant maintenance (1.5% of investment)		66,800
Payroll overhead (18.5% of payroll)		17,500
Operating supplies		7,400
Total direct cost		$763,300
Indirect cost		
Maintenance, supplies and 50% labor		62,300
Fixed cost		
Taxes and insurance at 2% of investment		89,000
Depreciation at 6.66%		296,600
Total operating cost		$1,211,200

Annual production: 500 tons/day × 350 = 175,000 tons/yr.
Operating cost: $1,211,200/175,000 = $6.92/ton.
Production cost: With 12% return = $6.92 + $3.05 = $9.97/ton

What Does Tonnage Oxygen Cost?

Analysis of commercially available oxygen separation plants yields useful cost data for low- and high-purity oxygen.

SIDNEY KATELL and JOHN H. FABER, U. S. Bureau of Mines, Morgantown, W. Va.

TONNAGE oxygen plants are available in sizes ranging from 150 to 1,000 tons/day. For plants in this range, capital requirement is estimated to vary from $5,400 to $14,700 per daily ton, depending on size, purity, cycle employed and discharge pressure of product. Similarly, operating costs before return on investment will vary between $4.80 to $10 per ton.

Several processes that can be utilized to convert coal to a synthetic pipeline gas or hydrogen require high-purity oxygen as one of the basic raw materials. Depending on the end product and its specific use, these processes will require oxygen of either 95 or 99.5% purity. In turn, the quantity of oxygen depends on the particular process and the size of the integrated plant.

A recent article[1] mentions leasing of facilities and compares this approach with the cost of direct purchase of equipment. It is not our intent to compare the alternate methods by which oxygen facilities may be acquired. However, a critical analysis by management of these alternates is necessary.

Another factor that enters into the complexity of an economic analysis of oxygen costs is the cycle employed to give a product of specific purity. Still another factor is the pressure at which the product is required. Since both factors will establish the power requirements, they must be clearly defined in any cost analysis.

In addition, others[2] point out that the only generalizations that can be made regarding oxygen plants is that there are no generalizations. Bearing these facts in mind, the following assumptions have been made for this article in order to present a representative cost analysis:

1. Location of plant: in the Ohio Valley.
2. Size of plant: 150 to 1,000

Low-Pressure Cycle Plant Delivers 95% Pure Oxygen

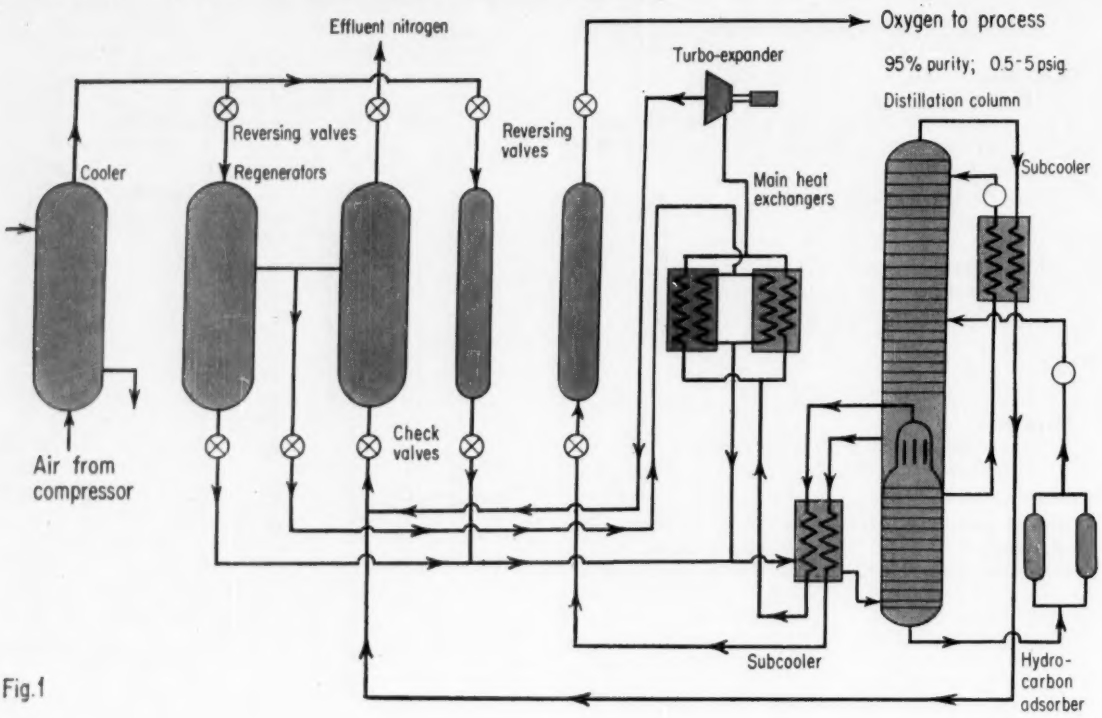
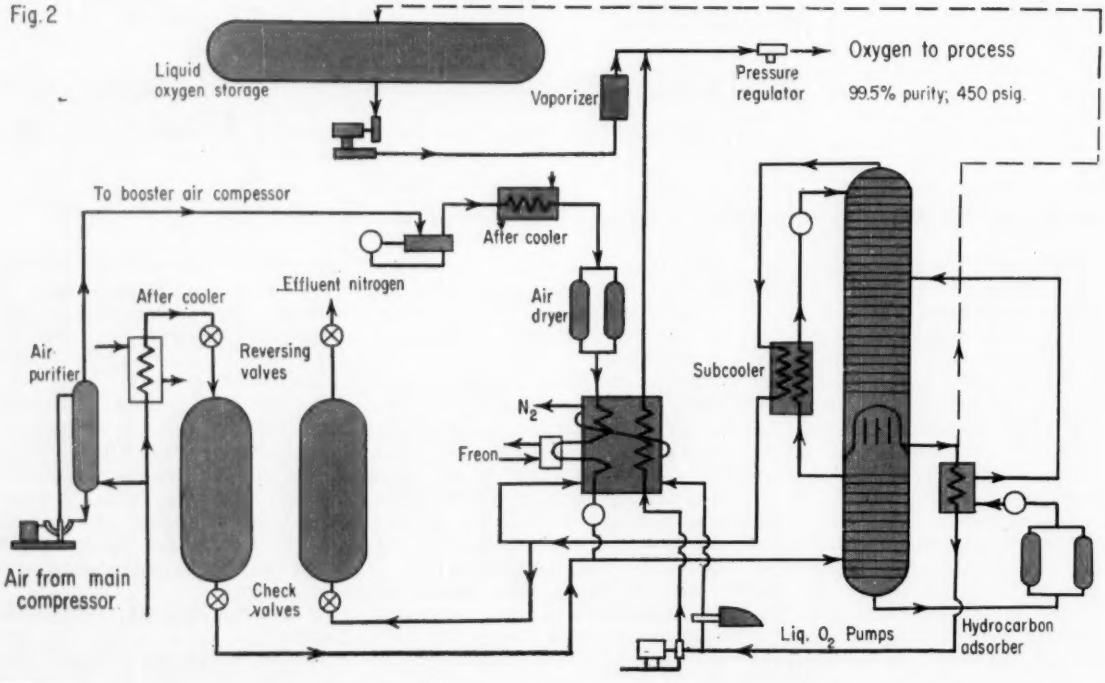


Fig. 1

Split Cycle Plant Yields 99.5% Pure Oxygen Plus Liquid Oxygen

Fig. 2



tons/day. For larger requirements, install multiple units.

3. Purity: 95 or 99.5%.

4. Pressure specifications: 450 psig. discharge.

5. Cycle employed: Low-pressure[3] shown in Fig. 1, or split stream[2] shown in Fig. 2.

6. Cost of available power: 7.5 mills/kwh.

Capital Investment Costs

Relationship between capital investment requirements and plant capacity is presented in Fig. 3. Curve *A* is for the split-cycle, air-fractionating process, which will deliver oxygen of 99.5% purity at a discharge pressure of 450 psig. Capital costs for the low-pressure cycle plant producing 95% oxygen at a pressure in the range of 0.5 to 5 psig. are represented by Curve *C*. Curve *B* incorporates the cost of compression to 450 psig. for the low-pressure system. The information in Fig. 3 was developed from data of oxygen-plant vendors.

The split-cycle system has been claimed by the manufacturer to offer greater reliability because it can produce a small quantity (3%) of liquid oxygen. This liquid oxygen can be stored and used during emergency shutdown.

Proponents of the low-pressure system state that, with slight modification, the latter system can produce a 99.5% pure product. However, neither claim can materially affect the economic aspects of this study.

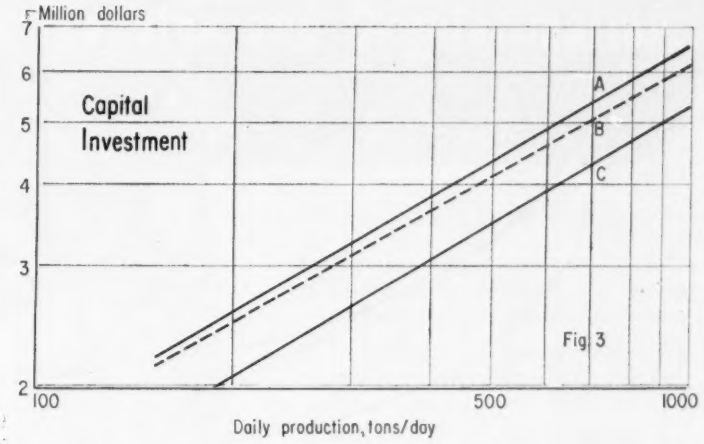
The relationship between power requirements and plant capacity is shown in Fig. 4. Since the low-pressure cycle produces oxygen at a discharge pressure of 0.5 to 5 psig., it is necessary to include the additional power required to compress the gas to the common discharge pressure of 450 psig.

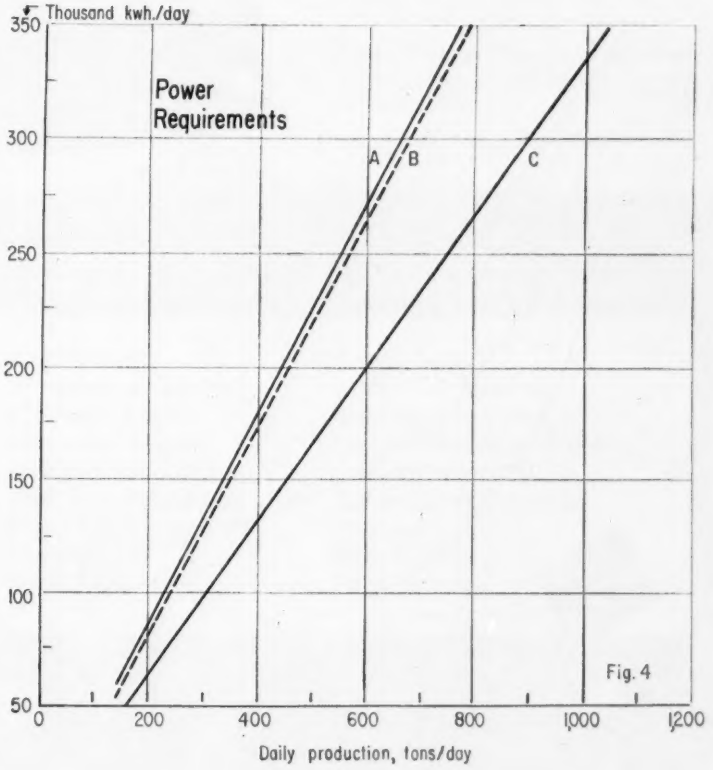
What Is Unit Cost of Oxygen?

Using the method shown in Table I, the operating costs for the tonnage oxygen plant were calculated. The results are shown graphically in Fig. 5. For the cost calculations, we assume the availability of power at 7.5 mills/kwh. and labor at an average of $2.50/hr. Plant maintenance was estimated to be 1.5% of the total investment, payroll overhead at 18.5% of payroll, and taxes and insurance at 2% of in-

Capital and Power Requirements for Oxygen Plants

Curve A: Split cycle plant: 450 psig. discharge; 99.5% pure oxygen.
Curve B: Low-pressure plant: 0.5 to 5 psig. discharge; compressed to 450 psig; 95% pure oxygen.
Curve C: Low-pressure: 0.5 to 5 psig. discharge; 95% pure oxygen.





Operating Costs and Selling Prices of Tonnage Oxygen

Curve A: Split cycle plant: 450 psig. discharge; 99.5% pure oxygen
Curve B: Low-pressure plant: 0.5 to 5 psig. discharge; compressed to 450 psig.; 95% pure oxygen.
Curve C: Low-pressure plant: 0.5 to 5 psig. discharge; 95% pure oxygen.

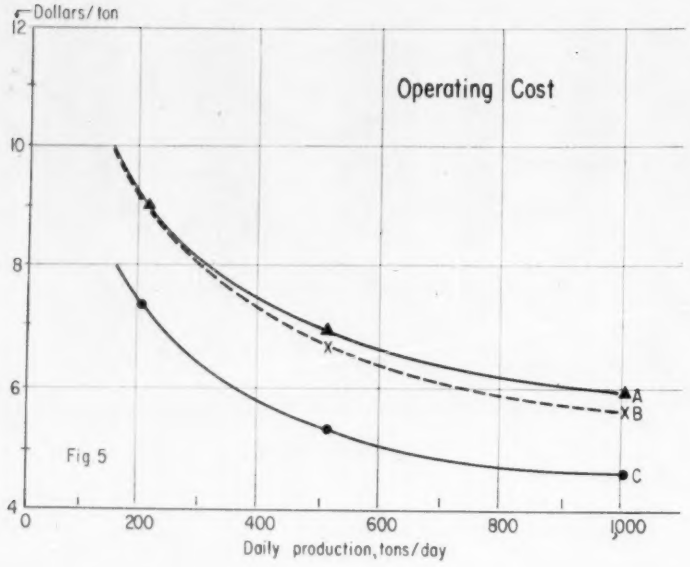


Fig. 5

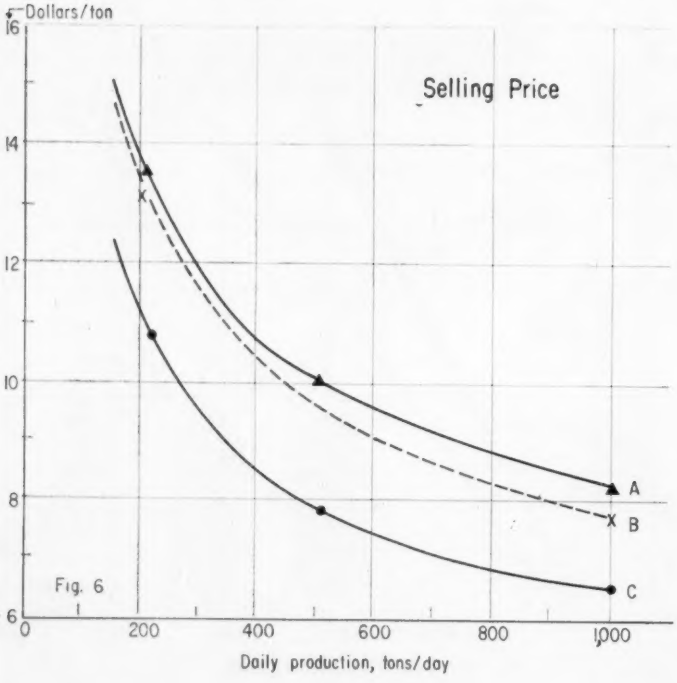


Fig. 6

vestment. Depreciation was established on a straight-line basis at 6.66% a year. Operating factor for the plant was 350 days.

Fig. 6 is similar to Fig. 5, except that a gross return of 12% on investment has been included by way of example. The gross return of 12% is based on the consideration that the oxygen plant is incorporated in a synthetic gas plant.

A variation in degree of any of the factors entering into the cost calculations can have a material effect on the over-all costs. To illustrate, an increase in power costs to \$0.01/kwh. will increase the operating cost of the 1,000 ton/day plant delivering 99.5% oxygen at 450 psig. from \$5.95 to \$7.09/ton. The last two figures are cost before return on investment. If we assume a 12% gross return on investment, these costs increase to \$8.25 and \$9.39/ton. An increase in gross return to 30% will result in a selling price of \$11.69 and \$12.83/ton.

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He is a registered professional engineer in W. Va. and is a graduate of W. Va. Univ. with the B. S. degree in chemical engineering.

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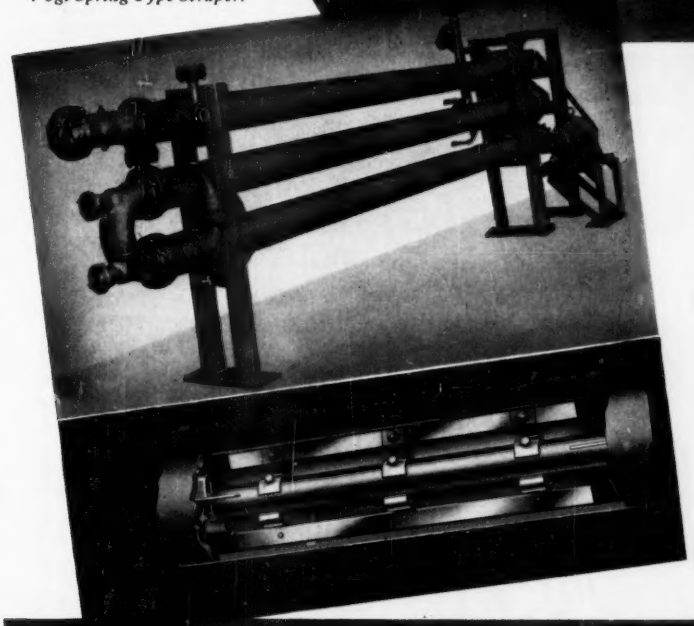

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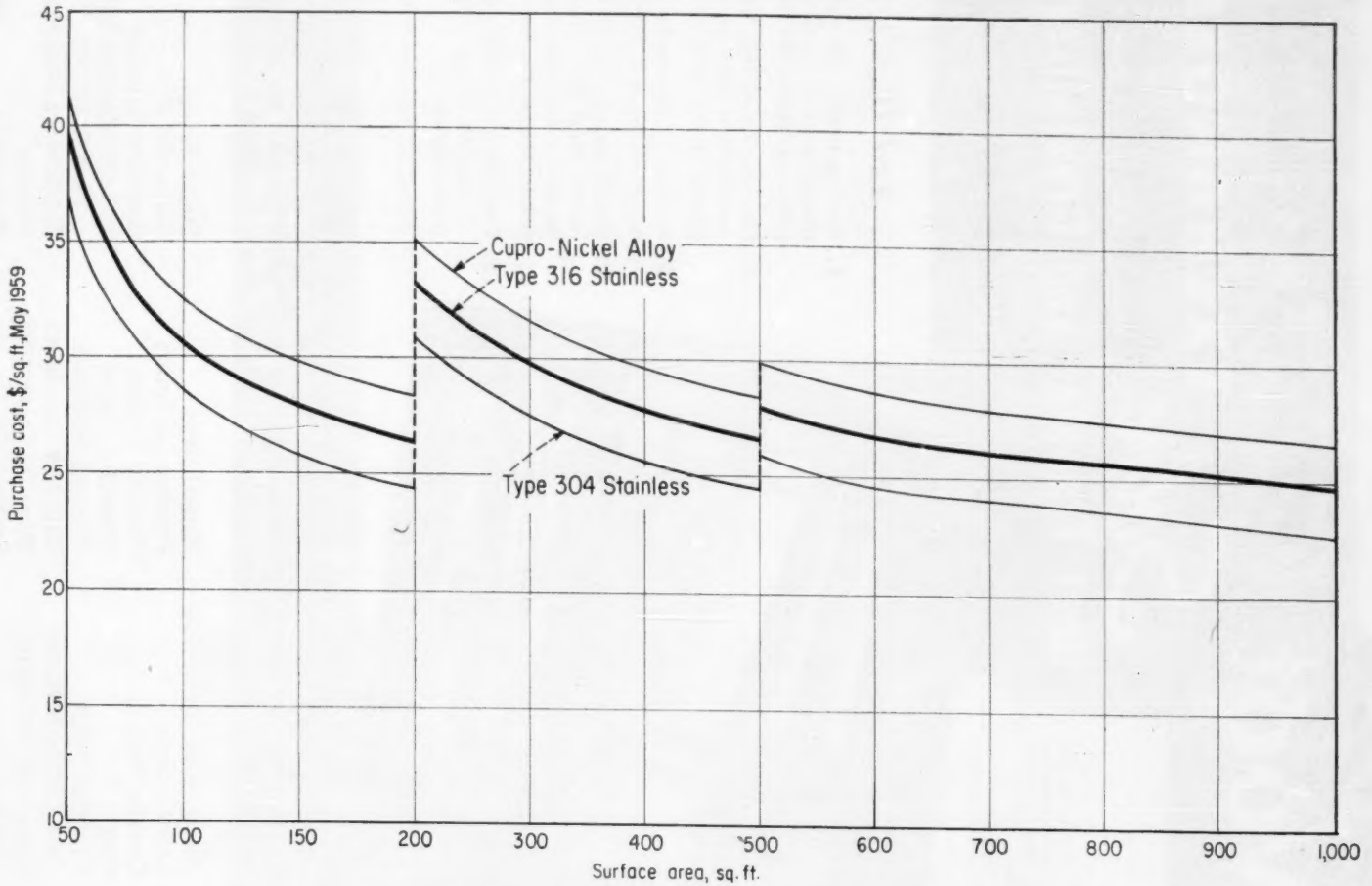

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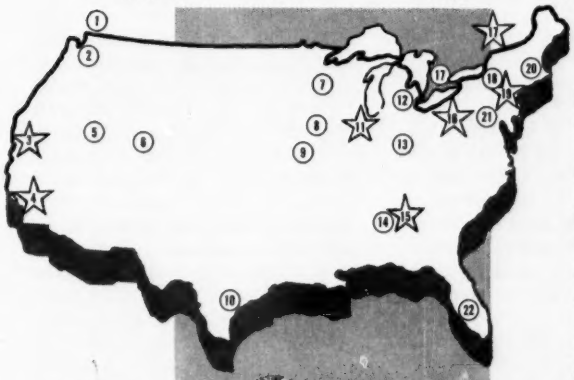

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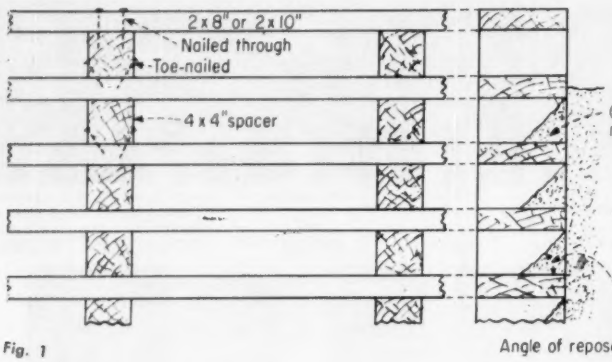


Fig. 1

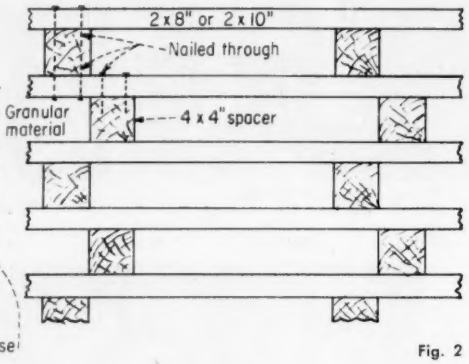


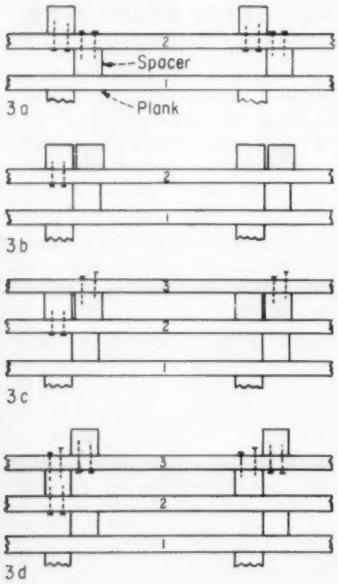
Fig. 2

Not this . . . . . But this

More for Your $'s With "Book-Case" Bins

Outside the fertilizer industry few people have ever seen such a bin. Yet, rectangular holes framed with a minimum of wood can do the trick.

Chesman A. Lee, Engineer, Evanston, Ill.



The "book-case" type of wall construction for bins has been used for many years in the fertilizer industry. Because it is cheap and easy to construct, and readily lends itself to bin layout revision from time to time to meet shifting requirements, it has possibilities that are worth consideration in other industries as well. Fig. 1 indicates the usual method of constructing such walls.

Some very plausible claims are made in favor of this type of construction, for example, that the fertilizer can expand into the openings to relieve the pressure; or that the pile can breathe through the openings and cure-out better. These claims, in common with most others, are completely without justification. The real justification lies in the low cost and simplicity of the method and in the fact that it speeds up construction of storage bins and retaining walls for storage areas.

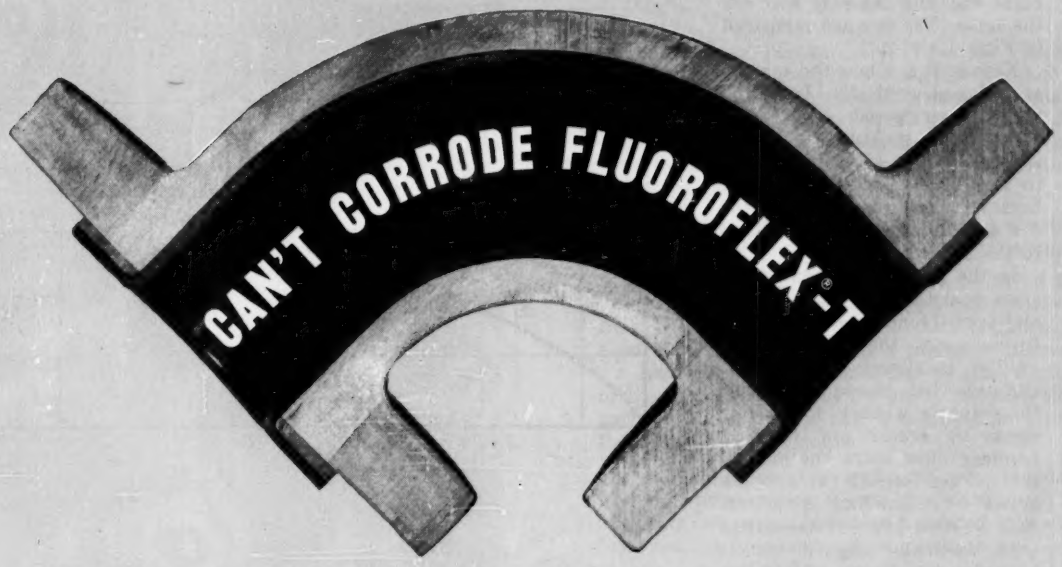
Cost is low because the wall consists of a series of rectangular holes surrounded by a minimum of wood—as Figs. 1 and 2 show. The method works for two reasons: First, the wall is much stronger against the lateral pressure of the stored material then it would be if made solid from the same amount of wood. And second, the material is retained, choking itself off at the angle of repose in strict accord with theory. This, despite the possible expectation that a granular material might be pushed through the openings by pressure towards the bottom of the pile. (Incidently, the wall pressure is exactly the same as if the openings were tightly closed.)

There is an exception to this

any acid

...in any concentration

...at any temperature to 500°F



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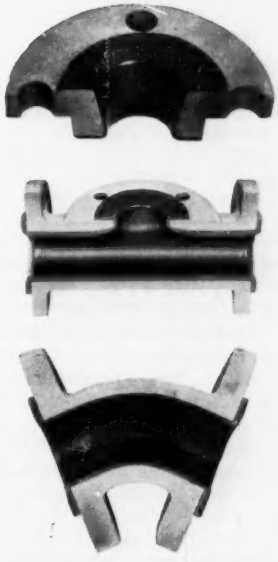

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method in the case of finely ground materials which aerate, for example, portland cement. It is impossible to retain such materials in a bin of this type.

Even for such a simple construction as the "book-case" bin, there is a right way and a wrong way—and an easy way and a not-so-easy way. Fortunately, the right way and the easy way are the same. The two are compared in Figs. 1 and 2.

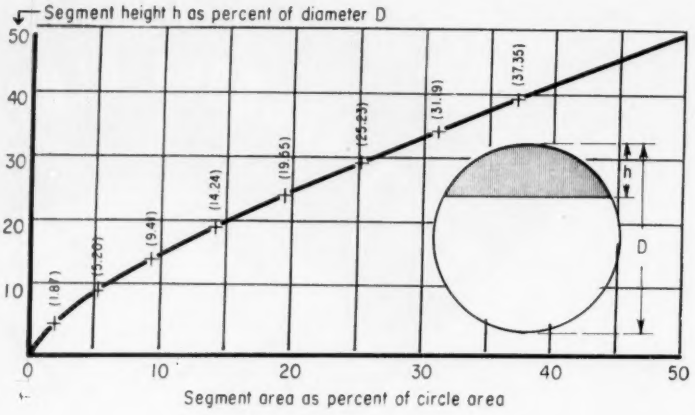
Note in Fig. 1 how the spacers are aligned vertically. In Fig. 2 they are staggered. The Fig. 1 construction makes a neat-looking job but it is more difficult to assemble and not as strong because of the way in which the 4 x 4-in. spacers must be nailed to the 2 x 8-in. planks.

In the Fig. 1 construction the spacers are toe-nailed to a plank and then the next plank is nailed through into the spacers. Toe-nailing is slower than nailing through—but worse than this, the joint is weaker, toe-nailing opens up cracks and the last hammer blow scars the side of the spacer. Smooth surfaces are better when handling chemicals. It is possible to avoid toe-nailing with vertically aligned spacers by using 2 x 4 spacers laid flat, but this is very uneconomical of wood. The practice of using toe-nailed 2 x 4 spacers on edge, still practiced by some plant men, is even poorer than the Fig. 1 construction since they are less sturdy than 4 x 4 spacers and sometimes split in nailing.

No toe-nailing whatsoever is required in the right way, portrayed in Figs. 2 and 3. Every joint is made by nailing straight down through the plank and into the spacer. Fig. 3 shows a simple trick which makes this possible. Assume the wall has reached the stage shown in Fig. 3*a*. First, lay out a set of spacers as shown in Fig. 3*b* and then spike a plank to them as in Fig. 3*c*. Turn the plank over, bringing the spacers on top, and then spike it down as in Fig. 3*d*. Two men working together on the scaffold can make good time in this way, producing a wall that is stronger and more durable, yet goes up faster and costs less than the alternate method of construction.

The problem of corner joints is easily handled by lapping the planks and using a 2 x 8 spacer. Sidewall joints (if the planks are not long enough) are made by staggering the plank ends so there is a continuous plank both above and below.

In the case of long walls it may be judged necessary to install internal tie rods. One way to avoid them is to program use so that a large bin will not be filled all the way up without filling an adjacent bin. If used, the tie rods must be designed to withstand vertical loading as well as tension. I have seen rods as large as 1¼ in. stretch and lose their tension.



Area vs. Height for Segments

P. V. Folchi
Consulting Engineer, Cincinnati 13, Ohio.

In two common types of application the chemical engineer is interested in the relations between the height of a circular segment and its area. One is in the design of baffles for shell-and-tube heat exchangers. The other is in the calibration of

NEXT ISSUE: Watch for Winner of June Contest

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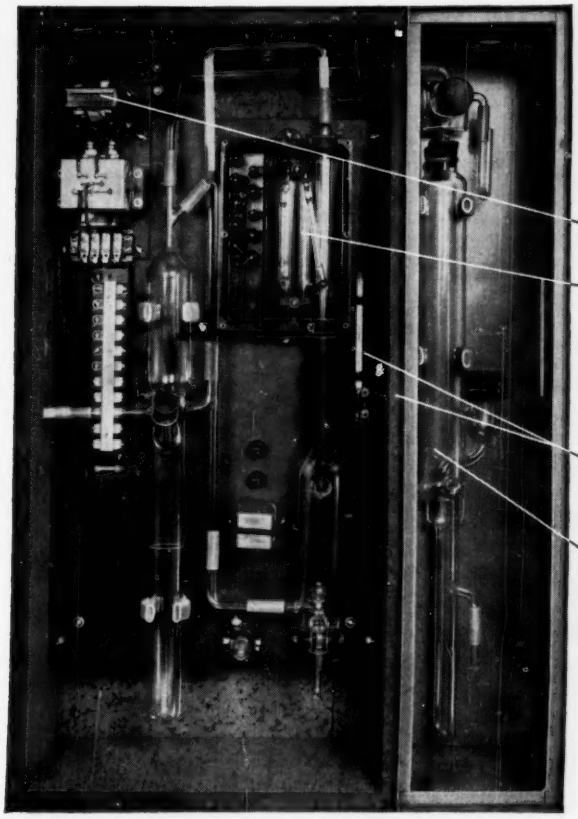

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In hundreds of plants, L&N's Thermal Conductivity Gas Analyzers are solving the problem of obtaining accurate, reproducible measurements of CO_2, SO_2, H_2 in N_2 and many other gases. Because they embody the benefits of thirty years' experience in process gas analysis applications, L&N Thermal Conductivity Analyzers . . . . .

1. Eliminate gas measurement upsets. A constant voltage regulator excludes a-c power variations.

2. Provide accurate measurements by using the unique L&N cell design which gives you vibration-free operation due to a rigid filament support . . . electrical stability by using a platinum filament . . . high corrosion resistance due to glass coating of the filament . . . and immunity to small flow variations because the cell is designed to utilize the gas diffusion principle.

3. Make reproducible measurements possible. Ambient temperature swings are eliminated by enclosing cell assemblies in an insulated case with thermostatically-controlled temperature.

4. Permit low maintenance and therefore minimum downtime as a result of the time-tested analyzer design including features such as flexible junctions, heavy glass construction, etc. Coal and asbestos filters remove mist and dust to assure cleanliness of the analyzer system.

5. Match the inherent accuracy and sensitivity of null-balance Speedomax®G and H Recorders.

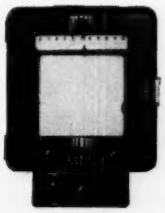
6. Permit selection of the particular type of control forms to fit the process. These include electric control, electro-pneumatic, and all-pneumatic controls—each designed to work with the Analyzer-Recorder system for maximum throughput.

7. Gives you undivided responsibility. The entire thermal conductivity system . . . sampling system, analyzer, recorder-controller . . . is designed, engineered and built by one organization with a nation-wide sales and service staff.

These "plus" features of L&N's Thermal Conductivity Gas Analyzers can help satisfy your demands for top quality products which lead to substantial savings. An eight-page booklet, Folder ND46-91(6) giving data on this equipment, is available by writing to Leeds & Northrup Company, 4955 Stenton Avenue, Phila. 44, Pa.

Speedomax H Series 60 Electric Control

Speedomax G Series 60 Electro-Pneumatic Control



Speedomax G Pneumatic Controller

LEEDS & NORTHRUP
Instruments — Automatic Controls • Furnaces

horizontal, cylindrical tanks for volume at various depths.

The accompanying chart serves both purposes. It is a plot of segment area vs. segment height, both expressed as percentages of the corresponding parts of the complete circle. The numbers along the curve permit plotting to large size. In use, for example, to find the height of segment you must cut off a baffle for a 25% open area, segment height will be 29.8% of D. Similarly, in the calibration of a tank, a liquid depth ratio h/D of 25% will correspond to a liquid-filled area of 19.6% of the tank cross section.

Simple Way to Find Specific Gravity

Surandra N. Srivastava
Dept. of Physics, Allahabad Univ. Allahabad, India.

The commonest method of determining the specific gravity of a solid is to weigh it in air, then weight it submerged in water. The loss in weight in water is the weight of water displaced, so (weight in air) ÷ (loss of weight in water) = specific gravity.

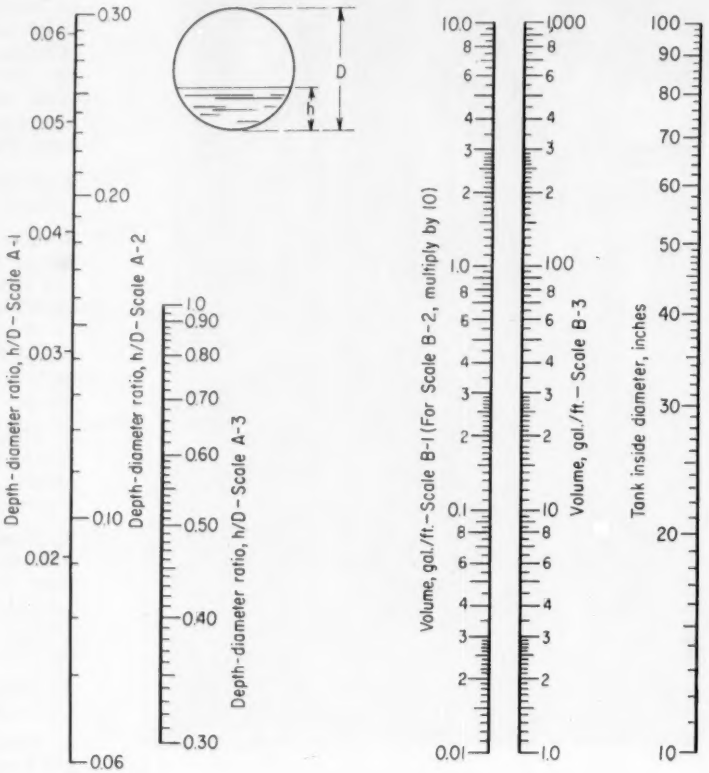
There is an easier alternate method that is not known to everybody. If we weigh a beaker of water and then suspend in the water the object whose specific gravity is to be determined, the increase in apparent weight of the beaker will be exactly equal to the weight of the water displaced by the object. It is necessary, of course, to make sure that the solid does not touch the sides of the vessel, that it is completely submerged and that there are no air bubbles attached to it. (To eliminate the air bubbles, see the author's method described in *Chem. Eng.*, Feb. 10, 1958, p. 150.)

Then, to find the specific gravity, divide the weight of the object in air by the increase in weight of the beaker.

This method is more convenient than the conventional one since it is much easier to find the gain in weight of the beaker of water by suspending the solid in it than to find the loss in weight of the solid when suspended in water.

If the solid is lighter than water, the customary method requires a sinker. With the present method it is only necessary to thrust the solid down into the water with a rigid wire.

A variation of this method easily finds the specific gravity of a liquid. First find the increase in weight of a beaker of the liquid, then of a beaker of water when a solid is suspended, dividing the first by the second figure.


D
h
Depth-diameter ratio, h/D – Scale A-1
Depth-diameter ratio, h/D – Scale A-2
Depth-diameter ratio, h/D – Scale A-3
Volume, gal./ft. – Scale B-1 (For Scale B-2, multiply by 10)
Volume, gal./ft. – Scale B-3
Tank inside diameter, inches

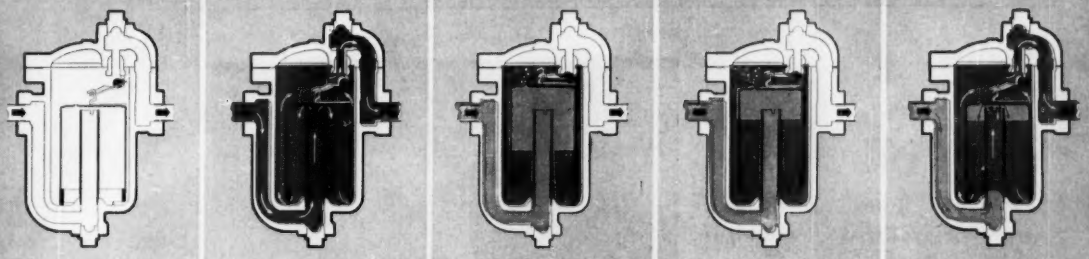
Calibration Chart for Tanks

Antonio Di Lorenzo
Engineer, Brooklyn, N. Y.

Chemical engineers often need to calculate the volume of liquid contained at various depths in horizontal, cylindrical tanks. Many different calculation aids have been offered to simplify this otherwise tedious task. The accompanying nomograph is one of the most convenient as well as most accurate methods available.

First find the depth-diameter ratio, h/D, and locate its value on one of the scales, A-1, A-2 or A-3. Join the point with the tank diameter and read the volume per foot of tank length on the correspondingly numbered B-scale (i.e., Scale A-1 and Scale B-1). For gallons in two bumped ends $V = 0.000933\ h^2\ (1.5D - h)$.

This simple trap operating principle provides the efficiency, dependability and freedom from maintenance necessary for the most profitable use of steam



When trap is first installed, the inverted bucket is down and the valve is wide open.

When steam is turned on, condensate (solid color) flows into trap and out through discharge orifice, until —

Steam (light color) reaching the trap floats the inverted bucket and closes the valve.

When more condensate enters the trap, the bucket loses buoyancy and pulls on valve lever.

When weight of bucket times leverage overcomes pressure on valve, bucket sinks and opens trap.

Key: condensate steam steam bubbles air bubbles

ARMSTRONG INVERTED BUCKET STEAM TRAPS

are designed and made to give you these big benefits:

● Amstrong Traps, the first inverted bucket steam traps, now represent the most advanced development of this time-proven principle. They provide all the advantages necessary for efficient, economical condensate drainage from virtually all types of steam using equipment.

1. *No steam loss* – Steam never reaches the orifice even when there is no condensate load.
2. *Automatic air elimination* – Vent in trap bucket passes air and other non-condensibles through to be discharged with condensate.
3. *No cooling leg required* – Condensate is discharged at steam temperature as fast as it reaches the trap because trap operates on difference in density between steam and water not on temperature.
4. *Operates on any back pressure* – Failure of one trap in system will not cause others to open because high back pressure does not affect an Armstrong trap other than to reduce capacity. As long as there is a pressure differential across the orifice the trap will close on steam and open for condensate.
5. *Unaffected by ordinary dirt* — Swirling action of condensate keeps dirt in suspension until discharged with condensate, prevents it from lodging in valve.
6. *Completely dependable* — Proved design plus the use of all stainless steel working parts assure continuity of service and length of service unmatched by any other trap.
7. *Big capacity in a small, economical package* — Armstrong design gives you the highest practical capacity for any given pressure. And remember, Armstrong capacity ratings are based on *hot* condensate at the *working pressure differential* stated, not on theoretical orifice capacities.

Further information on these advantages plus much additional information is given in the 48 page Armstrong Steam Trap Book. Ask your local Armstrong Representative or write direct.

860 Series for low pressure heating service.

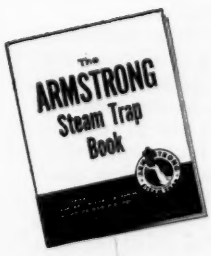
800 Series, side inlet, side outlet.

No. 801, side inlet, bottom outlet.

880 Series, integral strainer.

200 Series, bottom inlet, top outlet.

Forged Steel Series for high pressures, high temperatures.



The 48 page Armstrong Steam Trap Book tells how to correctly size, install and maintain steam traps for any pressure, any temperature, any load plus full catalog data on Armstrong Steam Traps. Ask for Catalog K.

ARMSTRONG MACHINE WORKS

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Monroe E. Spaght,
executive vice president
Shell Oil Co.; trustee,
Stanford University.

Industry Speaks Its Mind on Engineering Education

Are you satisfied with today's product of our engineering schools? Here's a top-management analysis of this important question.

A man accepting an invitation to speak his mind may be walking into a semantic trap. Taken literally, the phase "to speak your mind" means simply to say what you think.

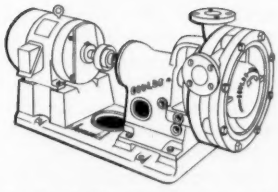
We all know the connotation is different. When a man says he is going to speak his mind, we somehow don't expect him to say that all is dandy, that everything is cakes and ale.

Since I have accepted your invitation, it becomes my duty to speak my mind—in the generally accepted sense of the word—and so I shall. But I shall try to do it without being any more impolite than necessary.

Our subject is engineering education. It is a special subject, but it has something in common with education in general. It's this: everybody who looks at it automatically becomes an expert by his own admission.

I am not sure why. Perhaps it is because there is evidence that things are not completely right with education in America, and any sign of weakness in anything so universally important brings out the Monday-morning quarterback in everybody. No country store was complete without its cracker-barrel politician who

IS THIS HAPPENING INSIDE YOUR PUMPS?



The Goulds-Pfaudler glassed pump is available in conventional hydraulic design, simplifying installation and maintenance. Four sizes with capacities up to 700 GPM, heads up to 140 ft.

When you pump corrosives, the inside of your pump *can* look like this. Or . . .

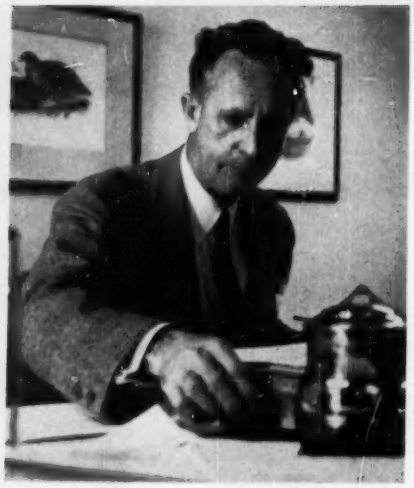
You can pump corrosives *without* corrosion with the Goulds-Pfaudler Fig. 3708 glassed pump. *Every surface that comes in contact with the pumpage* is protected by tough borosilicate glass fused permanently to the metal!

This glass-to-metal bond resists most acids at temperatures up to 350°F and alkalies at moderate temperatures.

You also prevent loss of product due to contamination, since glass is *inert*. Glass is *smooth*—discourages product adhesion and scale build-up.

For all the details, write for Bulletin 725.2 . . . plus a second booklet, "It's What's Inside That Counts," that gives you the inside story behind the new Goulds-Pfaudler glassed pump. Write Goulds Pumps Inc., Dept. CE-69, Seneca Falls, New York.

GOULDS GP PUMPS



You have been told that engineers do not know mathematics, science, spelling. Engineers are barbarians with slide rules.

had the answers to all of Washington's dilemmas, and nobody today is without his ideas on what is wrong with American education.

Every Russian satellite is a new demerit against our educators. Willie's bad spelling is for sure the fault of the school system. It is hard to think of a shortcoming in American life in the last few years that has not been blamed on education.

You have been generous enough to give me an audience, a platform and even an invitation to present a critique on a very important phase of American education.* My colleagues in industry join me in thanking you. I shall try not to abuse the privilege.

MANAGEMENT used to be respected; now it is judged.

You have been told that engineers do not know mathematics. Engineers do not know science. Engineers cannot spell. Engineers are barbarians with slide rules (meaning, I suppose, that they don't read novels or go to plays or listen to good music or seek inspiration in Greek philosophy). Engineers, in short, are without the means of grace or the hope of glory. Can a man then be respectable though an engineer?

Let's take an engineer's approach to the engineer's dilemma:

- First, let's get the facts.
- Then, let's consider what action within education might be appropriate in face of the facts.
- And then, let's back off and make some observations on the engineer's place in today's society.

First, how about getting some facts? How good are today's engineers?

A few weeks ago, I asked some of the senior technical people in my company to evaluate today's engineering graduates. The Shell Companies in North America employ over 10,000 people who have degrees from universities or colleges, and among them are 3,000 engineers, of whom almost 700 have advanced degrees. It may not be fair to take this group as representative of American professional engineers, representing as they do only ½ of 1%.

However, they do include all of the engineering disciplines, and they come from all parts of the nation, from many schools.

The people in our company who know engineers best, agreed to a man, that the young engineer coming to us today is vastly better educated than his counterpart of a generation ago. His knowledge of mathematics and science is distinctly better.

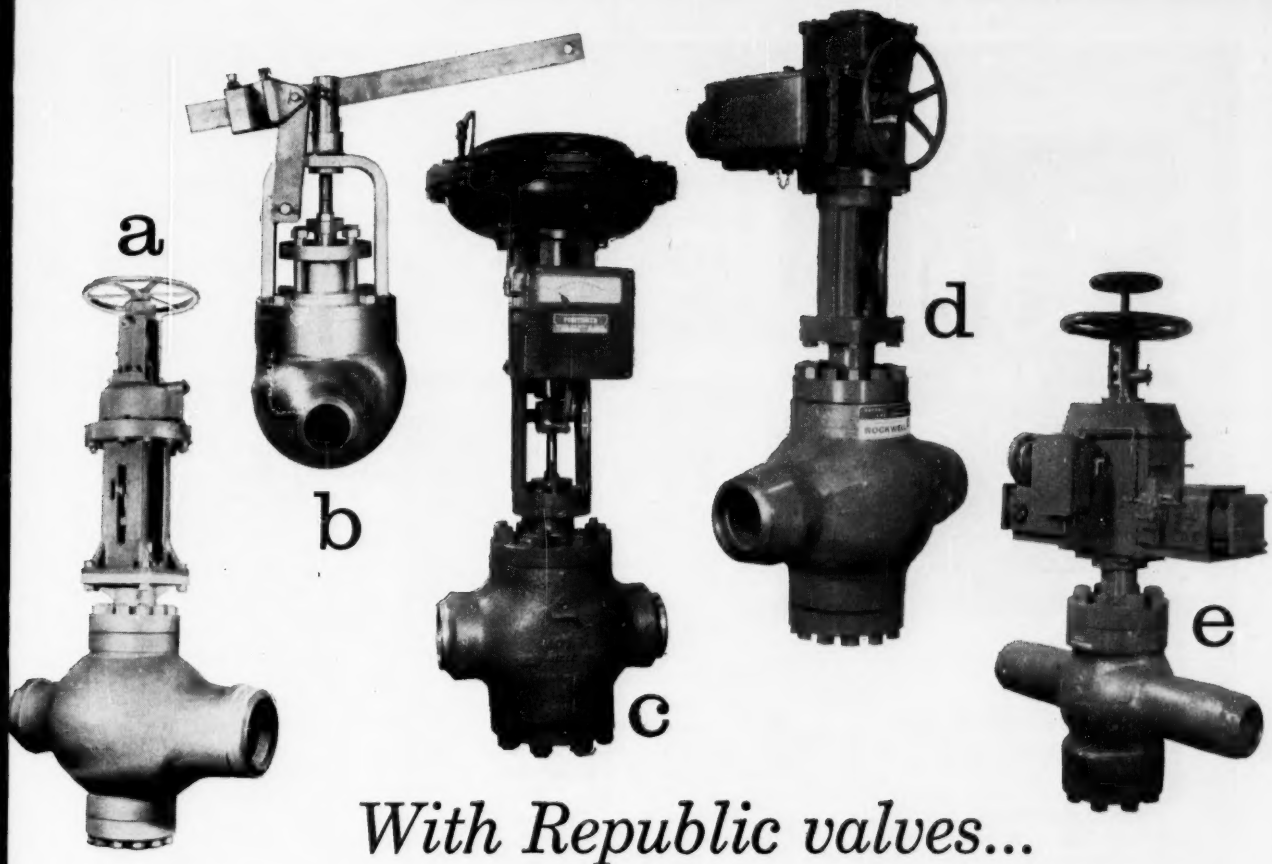
So much for the charge that young engineers do not know the basic principles of their trade. The plain fact is they do.

Next, my colleagues told me that the attitude of the young engineer has undergone a marked change in the last generation. I may be guilty of oversimplification, but I think it sums up to saying that he is not as hungry as he used to be. This leads him to be much more content to fit in and sink gracefully into a well-adjusted life. He happily becomes a team man and, quite out of keeping with the times, doesn't seem to be sold on the idea of "do-it-yourself."

LEAVE THE TRICKS of the trade to the employer.

This attitude manifests itself, too, in the new view of his sen-

* This article is condensed from a presentation before the Relations With Industry Div., American Soc. for Engineering Education, Houston, Tex., Jan. 1959. Permission granted.



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c. **Diaphragm operated valve**
d. **Motor operated valve**
e. **Toggle head operated valve**
f. **Diaphragm operated angle valve**

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The well-trained man can do almost anything better. Therefore, industry can well afford the extra cost he represents.

iors. As one put it: "Management used to be respected; now it is judged."

And then, what about the charge that engineers can't write or spell? And here echo answers true. The one criticism that ran through every report I got from our people was that young engineers are weak in grammar and spelling. This charge amounting to a statement that young engineers are not good enough at communicating about either the sharp details or the broad principles of their profession, is a serious charge. It does not overbalance our favorable findings of fact about mathematics and science, but it certainly deserves thought.

ENGINEERS ARE SCARCE
because they are cheap. Therefore, demand is high.

Now to our second main point: What immediate actions might be appropriate to the facts we have reviewed?

As for the matter of basic ability in mathematics and science, I would make only this suggestion, which I believe would be seconded by the majority of American industrialists. Keep up the good work in basic training. Let the young engineer spend his university years in acquiring basic knowledge. And let your engineering faculties stay abreast of new advances in knowledge.

They will have all they can do to keep up; and to keep their students reasonably well informed about the main events.

Of course, teach the student good mathematics, good physics, good chemistry and the basic courses in his specific field of engineering. But may I ask you not to consume his limited time teaching him the jargon and application of engineering to particular industries. Leave the tricks of the trade to his employer.

I make this plea for two reasons. First, such practical information can be acquired easily on the job, but acquisition of basic knowledge through study after leaving the university is more difficult. Second, not all students who take the so-called "practical" courses end up in jobs where they can use the knowledge, and I suggest that the transfer value of such technological information is relatively low.

Now let me make a direct and unmistakable objection to the pattern of effort made at making an individual "well adjusted." I know that I speak for many when I decry all efforts to pound the individuality out of everyone to the point where they all fit a standard and to despair of anyone who dares to depart from the will of the gang.

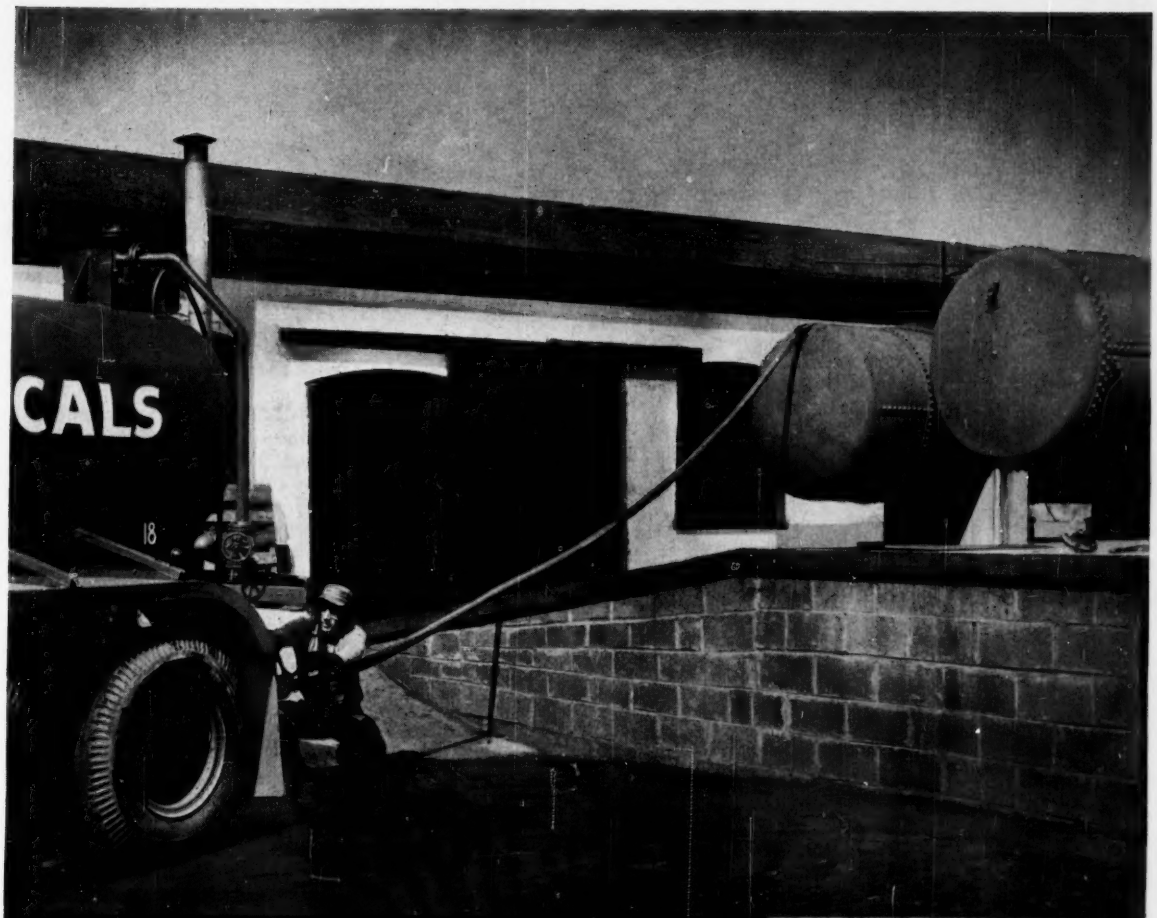
In my mind, such efforts constitute one of the biggest pieces of nonsense that has ever permeated the thinking of a society. Industry, like a university or a country, prospers through the labors of the uncommon man. There can be no surer sign of the end of greatness than the end of willingness to tolerate the unusual person.

So much has been said on this subject that elaboration is not needed from me. But I want to tell you most earnestly that I would never ask for the young products of our engineering schools to be so wedded to the idea of "fitting in" that they are afraid to raise their voices in protest against what they may find when they come to us.

And now, with your tolerance, let's back off and take a broader view of the engineer's place in today's society.

Certainly his place is critically important. The engineer has no need to apologize for his calling or for the general character of his education. A barbarian with a slide rule? Not by a long shot.

The definition of an educated man changes with time. Our idea of culture is quite different from that which prevailed during the Golden Age of Greece or during the Renaissance. I yield to no man in my enthusiasm for sound courses in language, in history and philosophy as requisites for any university degree anywhere. But it seems to me that one can



Better than any other acid hose we've ever used

After handling many makes of acid hose the chemical operator at this plant has found that Acme-Hamilton acid discharge hose is outlasting the others, remains flexible even when cold, and is highly resistant to weathering. This A-H hose has been in service 2 years conveying 2,000 gallons of commercial sulphuric acid per week.

Acid Discharge Hose

(A) Cover. Tough abrasion and acid resistant rubber. Hose ends are rubber sealed.

(B) Carcass. Multiple fabric plies withstand pumping pressures, provide high degree of flexibility.

(C) Tube. Pure gum: will handle wide range of acids, salts and alkalis. (Can also be furnished with Hypalon* tube for special applications.)

Write Dept. C-1. *Du Pont T. M.

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Men who know engineers best agree that the young man coming to us today is vastly better educated than his elders.

make an equally strong case for requiring basic instruction in science and mathematics for any university degree.

Who, then, is the barbarian? Or, to be less savage, who is less than perfectly educated? Is it the engineer, with his proficiency in basic knowledge and manipulation of the physical world, yet with only a fair knowledge of history and maybe even an admitted weakness in spelling? Or could it be the charming man of letters with his brilliant ease among the glittering generalities of the arts, and yet with a skill in mathematics that ends with balancing a check book and a knowledge of chemistry that stops at making martinis?

If we agree that engineers are reputable characters, let's see how they are being used. How is society treating them? The answer is somewhat depressing.

We in American industry are often flagrant offenders in the practice of using engineers in nonengineering jobs. The temptation is obvious. The well-trained man can do almost anything better than the untrained man. In so many instances, the well-trained man is so much better that industry easily affords the extra cost he represents.

You see here the working of a simple economic law: So long as the trained man can be had at his present rate, he can be afforded for use in occupations that draw only lightly on his store of talents.

A friend of mine has said that scientists and engineers are short because they are cheap. That is, their value is beyond their cost. Therefore, the demand is high. Therefore, the supply is inadequate.

We can object to this, but as long as the driving force is there, I can see no early end to the practice. In our democratic system, we don't order young people to become scientists or engineers. When they get their degrees in science or engineering, they go to work where they please. Nobody allocates the limited supply of precious talent for the officially determined good of the State.

In a free society, natural forces are allowed to determine the distribution. But in the current world situation, if our free society does not give thought to the possible consequence of this use of scientific and engineering talent, the results could be serious.

And this brings me to a last point: the possibilities for improvement. It must be obvious that I for one consider engineering education to be at the very center of the enormously complex questions involved with our survival—not to mention our continued growth—as a free nation.

If, as I believe, the well-rounded, educated man is the foundation of the bulwarks of freedom, I would begin my list of possibilities for improvement with the suggestion that charity begins at home, with engineering education. Let's never rest in our efforts to make it, or keep it, the very best that can be had; constantly reviewing, testing, questioning, criticizing so that our young graduates know their business as engineers and as members of their society.

Let's quit misusing talent. Perhaps you can help us in this. Maybe the profession at large can also.

But then we come to the real chore: getting the public to understand the problem.

The problem? What problem?

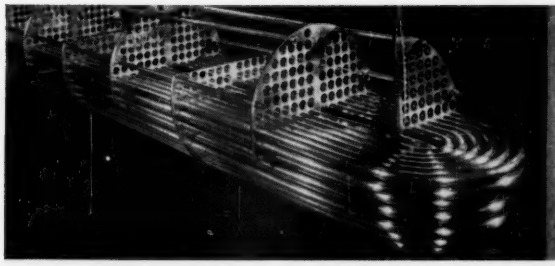
The problem that is brought into focus by the case of the high-school teacher who resigned and went to work driving a truck for a brewery so that he could support his family.

The problem that caused a State university in the Southwest to announce recently that it had turned away students in significant numbers from courses in mathematics, physics and engineering because money for teachers in these areas was not available.

The problem that we see when school boards throughout the nation refuse to raise the pay of their teachers; when districts refuse to approve the issuance of bonds to build minimum school facilities; when our Government votes money for highways and not for schools.

The solution of the problem?

I can see it only as a long job of education, not accomplished by one speech, or one article, or one spring's drive, but a job pursued endlessly. In today's world there is no such thing as staying fat, dumb and happy. We must do whatever we can, wherever we are, in asking and arguing for more and better education.



CONDENSER AND HEAT EXCHANGER CLINIC

Edited by David S. Hibbard, Metallurgical Engineer
The American Brass Company, Buffalo 5, New York

New tube mill equipment gives designer of heat-transfer units freer hand in meeting new trends

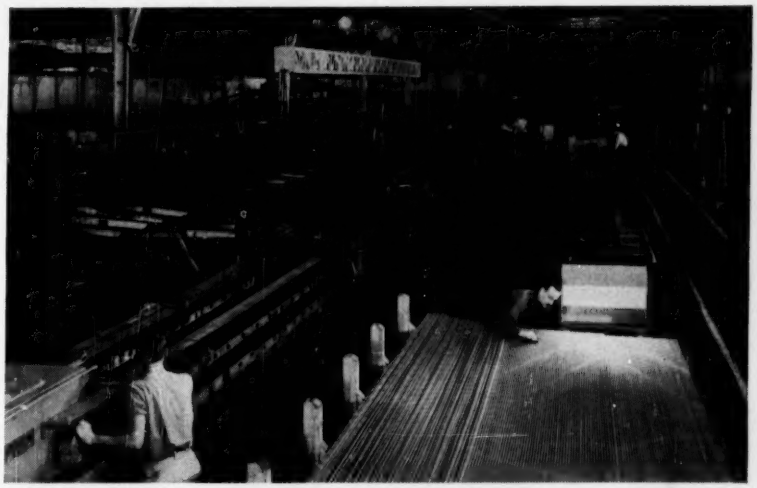
With the installation of new production and testing equipment, The American Brass Company now offers the most complete service available to users of condenser and heat exchanger tubes.

Long lengths. To gain advantages in construction, processing, or installation, designers can lengthen equipment considerably. Tubes can now be drawn up to 100 feet. Most of the longer tubes are required as U-bends, but in some instances may be shipped as straight lengths.

U-bends. Tubes from $\frac{3}{8}$" O.D. to $1\frac{1}{2}$" O.D. with wall thicknesses from .049" (18BWG) to .134" (10BWG) can be bent on a radius of from $1\frac{1}{4}$ times the tube O.D. to 30".

Dual Gage. Where high temperatures and pressures are involved, it may be desirable to thicken the tube wall in the area of short-radius bends on U-bend tubes. Walls are thickened one Stubs' Gage No. to compensate for thinning of metal in the bending.

Thickened Tube Ends. To compensate for thinning by rolling or by impingement corrosion caused by high velocities, tubes may be supplied with the wall thickened at one end one or more Stubs' Gage Nos. The extra thickness may be on the outside or inside of the tube as required.



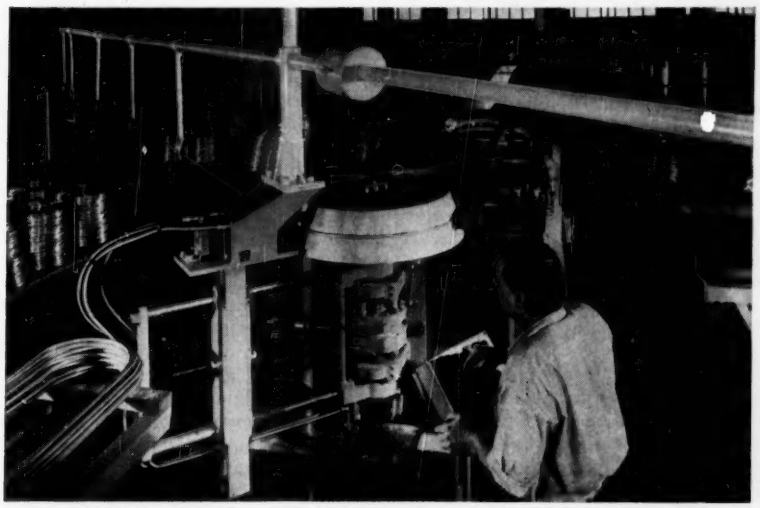
GENERAL VIEW of new American Brass Company equipment which can draw copper and copper alloy tubes in lengths up to 100 feet.

Relieving Stresses. All U-bend tubes, other than copper, are annealed at the bend area after bending, to eliminate the hazard of stress-corrosion cracking which might occur in service due to stresses that may exist as a result of the bending.

Testing. U-bends are tested hydrostatically at ASTM Specification pressures —or at ASME Code pressures up to 6000 psi on request, if the tube size will stand it. Electronic inspection with eddy-current equipment is available also, when required.

Shipping. U-bend tubes are shipped packed for ease in handling and storage.

Technical Assistance. For more detailed information on extra-long tubes, U-bend, Dual-gage, or Duplex tubes to meet special problems, address: The American Brass Company, Buffalo Division, Buffalo 5, New York. In Canada: Anaconda American Brass Limited, New Toronto, Ont. 5567 Rev.



BENDER CAN produce U-bend tubes with straight leg up to 50' long.

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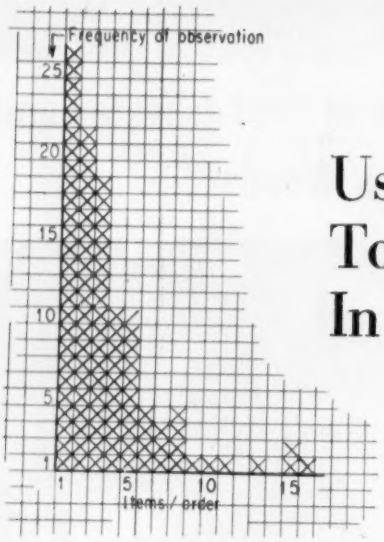

Use Elementary Statistics To Reduce Costs In Materials Handling

Engineers and managers have learned through bitter experience that stating or defining the problem is essential to its solutoin. What some engineers have not learned is that there now exist statistical techniques for analyses of the numerical aspects of a problem that can be of great help in its eventful solution.

Our purpose is to bring to your attention several basic statistical tools, and to suggest ways they can be applied to materials handling.

Statistics can be defined as the study of variability. We all know that physical phenomena and operating data are subject to variability.

For example, a single order may require a stock picker to withdraw anywhere from 1 to 50 different items, of various sizes. Specifying the equipment for this operation then becomes "averaging" to get a "typical" order size that fits a large number of the orders received. In doing this, and we all have done it, we recognize the variability of number and size, and try to arrive at a reasonable solution by "seaman's eye," or "common sense."

In many cases such a rough averagi· g is good enough. Indeed, we have worked on this basis for years. And the gains possible through applying only the experience and judgment of a good materials-handling engineer are substantial.

At present, however, much of the "cream" has been skimmed. In many companies the day of the spectacular project is over. Among all engineers there's recognition that materials handling is competing for capital expenditure money against all other aspects of the operation. This leads to a need for better analysis techniques, and a more precise way of analyzing variables in a problem. In other words, return-on-investment margins are shrinking in the typical material-handling problem.

We don't mean to suggest that statistical technique ever will replace common sense, judgment or experience. These are the qualities essential to the application of statistical techniques.

But many engineers, particularly those ten years or more beyond college, never have had training in statistics. In many engineering colleges, the subject isn't required. Practically speaking, the basic tools in statistics are the most useful and the most easily mastered.

Classifying and Collecting Data

Usually we recognize problems as problems because some bit of data seems to contradict our judgment of what this particular number should be. This requires, of course, that the data be labeled clearly, and that the collection be done so that the data are accurate.

For example, a common figure used in appraising space utilization is an index of cube space used to cube space available. To compare two such figures, the same rules must be used to derive each index. Similarly, cost/fork-truck move, or any other expense incident to unit costs, can be compared only if equipment expense is calculated in a uniform manner.

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ing data filtered through log sheets, registers, and so forth. It's wise to go to the source of data and satisfy yourself that the data mean what you think they mean. This is an obvious but necessary point.

Simple as these notions are, it's surprising to realize that many times the analysis from which a decision is made is haphazard indeed. For example, one firm purchased four 8,000-lb.-capacity fork trucks on the basis of load reports that indicated such capacity would be needed for 30% of the moves.

Closer examination showed that the load reports consolidated shipments by invoice number, and that in only 1 out of 50 moves was the large truck needed. Also, the number of moves of relatively small loads had been understated.

In another case, log sheets indicated that three cranes in a bay were busy almost continuously. Checking revealed that busy to the operator meant simply that he was in the cab.

Many plants today have unsuitable equipment whose purchase was the result of a less-than-thorough analysis.

Frequency Distributions

To reduce data to some manageable form, a device known as a frequency distribution is used. A frequency distribution may be constructed by using check marks on ordinary cross-section paper. Ordinate is the frequency or number of times a given value has been recorded; Abcissa represents the values of the measure analyzed.

For example, if the number of items in an order is the figure in question, we list across the abscissa the range of values from minimum to maximum expectable. Then, we go through groups of typical orders, checking the number of different items.

Actually, such a presentation, shown on the previous page, is called a frequency histogram. But the general scheme of presenting the relative frequency of occurrence of values is to smooth the histogram into a curve. Such curves, or distributions, are the common means of describing variability.

When this visual presentation is combined with certain numerical measures, it's possible to analyze and compare variability in a systematic manner. In addition, certain phenomena result in characteristic frequency distributions.

Bell-shaped Is Normal

The normal frequency distribution is a familiar bell-shaped curve. Special mention is made of this because:

- It's very useful in certain quality-control applications, and in representation of chance-cause errors distributions.
- You must beware of the misconception that most distributions are normal. Quite the reverse is true. The normal curve represents several of the measures encountered in engineering, but is by no means universal.

Averages of samples, some physical phenomena, and errors due to chance-causes alone, generally are distributed normally. Much is known about the normal distribution, and it is most useful in sampling and setting of limits of error.

Where does the normal curve help in the analysis of a materials handling problem? First, in any application involving automatic weighing. By establishing the variability of errors, predictions can be made concerning the extent of overweight and underweight packages. This also helps appraise the suitability of weighing and filling equipment.

Applications of this theory range from the filling of peanut-butter jars to the filling of bags with chemicals and cement. Coupled with sampling and the control chart, tolerances in weight can be reduced, and worthwhile savings effected.

Other Distributions

But what of distributions that aren't normal? Look at the chart. Most frequently occurring set of number of items in an order is 1. Average number of items is approximately 4 and median (value which half of the orders exceeds, and half does not) is 8 items. So designing equipment for the "average" will not fit one-fourth of the orders. At the same time, to design for the maximum of 16 when the most usual number of items is 1 seems costly.

Further examination revealed that the five orders with the greatest number of items were new accounts. While these had a large number of different items, there were only a few of each, and the bulk was not great. Use of three standard cartons now enable all but 1½% of the orders to be packed in one carton.

An extension of this type of analysis is used by airlines in calculating weights for baggage. Also, at least one steamship company has investigated typical cargo crate sizes, to plan stowages in holds.

Sampling Is Important

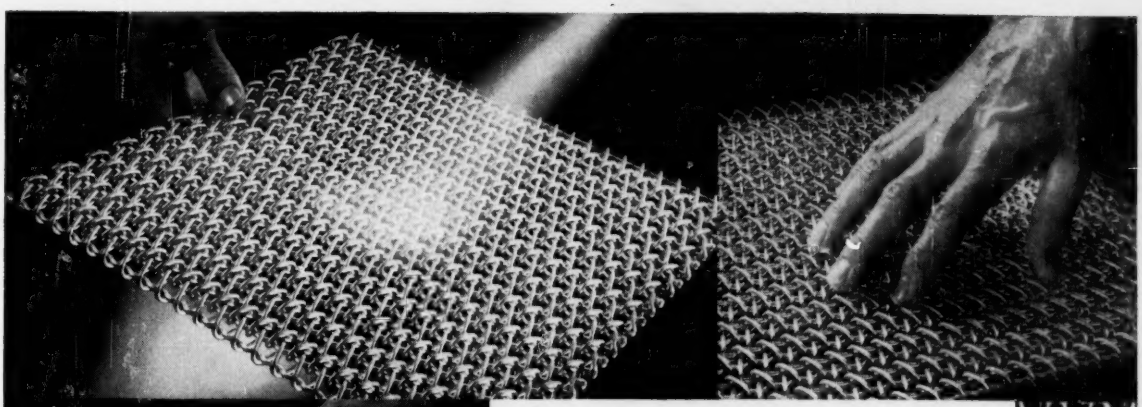
Next basic concept is sampling to obtain facts. We all form opinions on the basis of samples, but we recognize an element of doubt remains in all sampling. This should be no drawback, provided we remember two things:

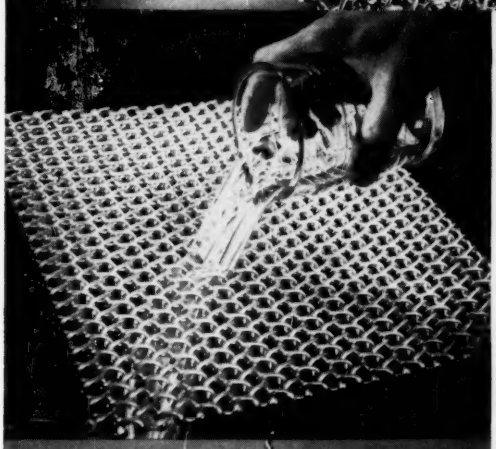
- Generally speaking, reliability of a sample increases as a function of the number of items in the sample.
- Great care must be taken to ensure that the whole from which a sample is drawn is well defined, and that the sample is drawn properly (without bias).

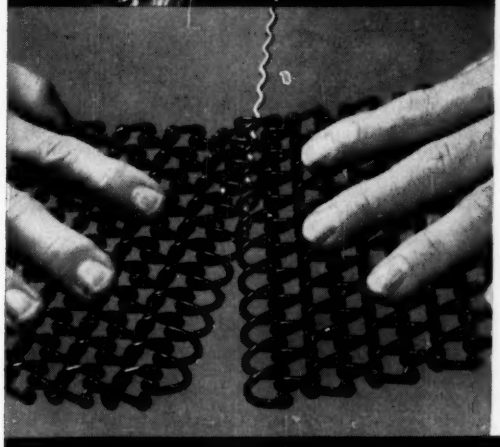
Since we deal with many variables in materials handling, and usually with large volumes of items, sampling is an appropriate fact-finding technique. Most statistical techniques used in connection with sampling involve determination of the differences between a sample and the whole from which it was drawn.

Work sampling is used to determine personnel and equipment utilization, but sampling should not stop at that point. Sampling can be used to determine average weights, proportion of items with any given characteristic, and in the analysis of any phase of materials handling. It may not be economical to consider all shop orders, all bills of lading, or all move tickets. Nor can we economically measure all containers, or reinspect all drums for broken sealing devices. But we can sample all of these to get our information.

This article is based on a paper titled "Use of Elementary Statistics to Analyze Materials-Handling Problems" by Wallace J. Richardson of Lehigh University, delivered at the ASME annual meeting in New York, Nov. 30-Dec. 5, 1958.







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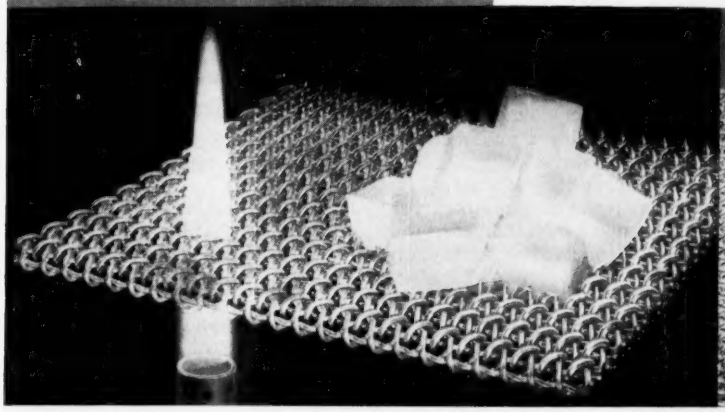
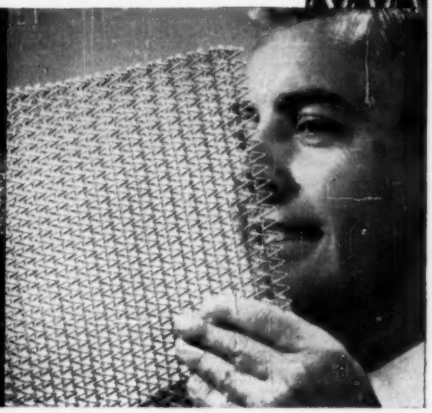
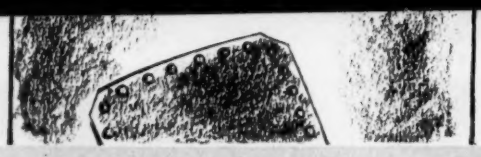


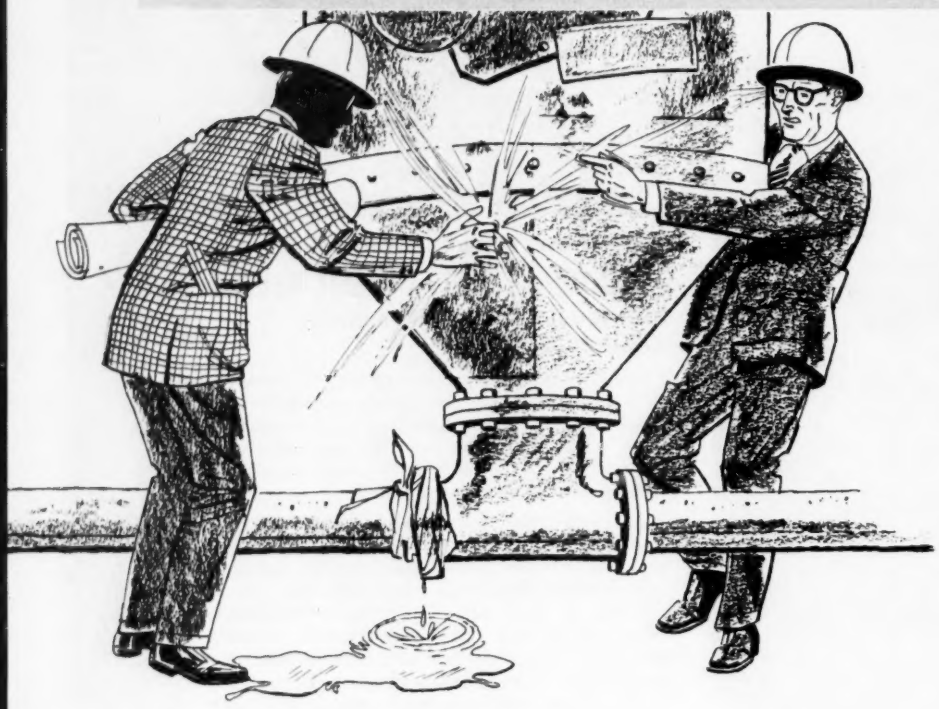




PRACTICE ...

CORROSION FORUM

EDITED BY R. B. NORDEN



Prime Reasons for Metal Failures

Based on a survey of eight chemical plants and nine oil refineries, here are main causes of metal failure in process applications, and what to do about them.

G. A. Nelson, Shell Development Co., Emeryville, Calif.

As the drawing above points out, the ideal chemical plant operating continuously for long periods is rarely attained. Shutdowns are required—some unavoidable, others should have been avoided.

Fouling, loss of catalyst activity, a revamp, metal failures are some of the causes of shutdowns. Probably a major cause is metal failure.

To determine the extent to which material failures contributed to plant maintenance, we recently conducted a survey of eight chemical plants and nine oil refineries. It was found that materials failed about 60 ways when exposed to rigorous chemical environments. But the important failures could be traced to some sort of metallurgical phenomena. We grouped these prime causes under headings and came up with a table such as shown on p. 134. This is a useful checklist to use when a new plant is under design or an old plant is to be remodeled.

As might be expected, two important categories show up: temperature and corrosion. By temperature we mean the area where you have gaseous environments, not aqueous.

G. A. NELSON, staff metallurgist at Shell Development, is active in ASTM and ASM. He worked for National Lead and American Smelting and Refining before joining Shell.

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► **Temperature Problems**—Problems created by temperature alone in steel are usually due to phases initially present in the steel or by precipitation of compounds after exposure to high temperatures. Low-carbon steels tend to resist brittle fracture; 885° embrittlement occurs when a chromium-phosphorus compound precipitates (avoid such steels); graphitization is the breakdown of iron carbide into graphite and iron particles (avoided by using a steel containing 0.70% Cr min.); sigma embrittlement in high Cr and austenitic stainless is created by a precipitate of Fe-Cr phase along the grain boundaries (use alloys free of this formation).

Temperature combined with stress presents serious creep and fatigue problems. And, of course, steels exposed to hot gases are subject to oxidation, sulfidation, hydrogen attack, carburization (diffu'on of carbon monoxide into steel). For a detailed discussion of these effects, see *Chem. Eng.*, Dec. 15, 1958, pp. 137-147.

► **Corrosion Problems**—The second category of problems in chemical plants, which we will cover in more detail, involves handling aqueous chemicals.

Note that some processes require special metals throughout the plant. For reasons of product degradation by contact with steel, loss of color in the product, or general corrosion, these plants are usually engineered with commercially-available special metals. In others, the reactions are so severe that nonmetallics are required and in some cases use is made of the high priced metals such as tantalum, silver, molybdenum, zirconium and titanium.

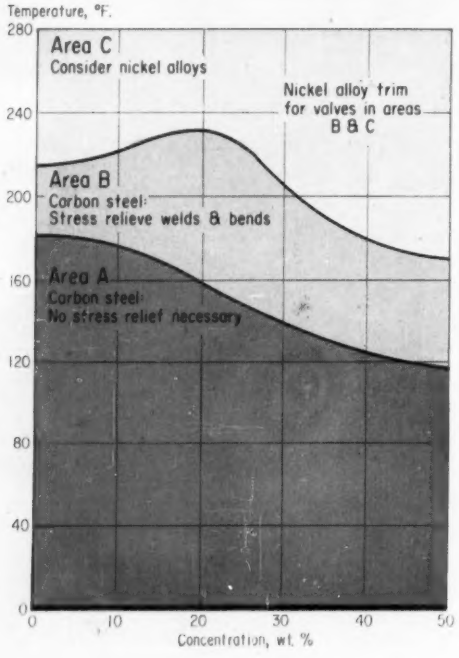
When process conditions demand special treatments of steel or special alloys to control corrosion, several interesting metallurgical problems arise. All metals have properties which must be considered from a fabrication standpoint so finished equipment will not fail when subjected to corrosive environments. Phenomena such as hot shortness of silicon bronze and the Hastelloys, tendencies of certain metals to crack when stressed in the presence of certain corrosives, galvanic corrosion of dissimilar metals are examples of these problems.

The survey of problems encountered in oil and chemical plants revealed the corrosion items in the table, which are prime sources of plant maintenance.

General corrosion, of course, has many ramifications and special skills are needed to diagnose and recommend process changes which will control it. We will not attempt to discuss this type of situation, but will go into some of the special problems in corrosion.

Hydrogen Blistering—For instance, hydrogen blistering occurs when steel is exposed to certain aqueous corrosive media in which atomic hydrogen develops as a result of corrosion. The atomic hydrogen permeates steel and collects in discontinuities such as inclusion stringers or voids and transforms into molecular hydrogen. When a critical amount has collected, pressures are created of sufficient magnitude to either raise a blister on the steel surface or to crack it internally. The lower quality steels having more inclusion stringers are more prone to develop blisters than high-quality steels. Attack of this type is quite rare and is found prin-

Caustic Soda: Temperature Ranges for Pipe, Valves



In Design, Watch for These Main Causes of Metal Failures

Temperature Only
- Brittle failure
- Aging
- 885° embrittlement
- Graphitization
- Sigma formation

Temperature Plus Stress
- Creep
- Thermal stresses
- Thermal fatigue

Temperature Plus Gases
- Air and oxidizing gases
- Hydrogen sulfide
- Hydrogen
- Hydrogen plus hydrogen sulfide
- Nitrogen
- Carbon monoxide
- Vanadium pentoxide

Corrosion Only
- General corrosion
- Hydrogen blistering
- Galvanic corrosion
- Intergranular corrosion
- Groove corrosion
- Dezincification
- Graphitization of cast iron

Corrosion Plus Stress
- Stress corrosion cracking
- Stress corrosion
- Corrosion fatigue

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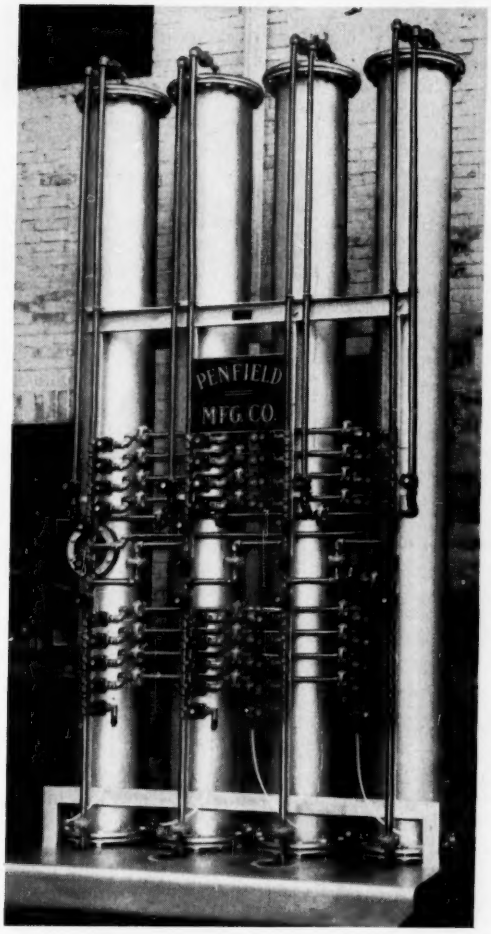

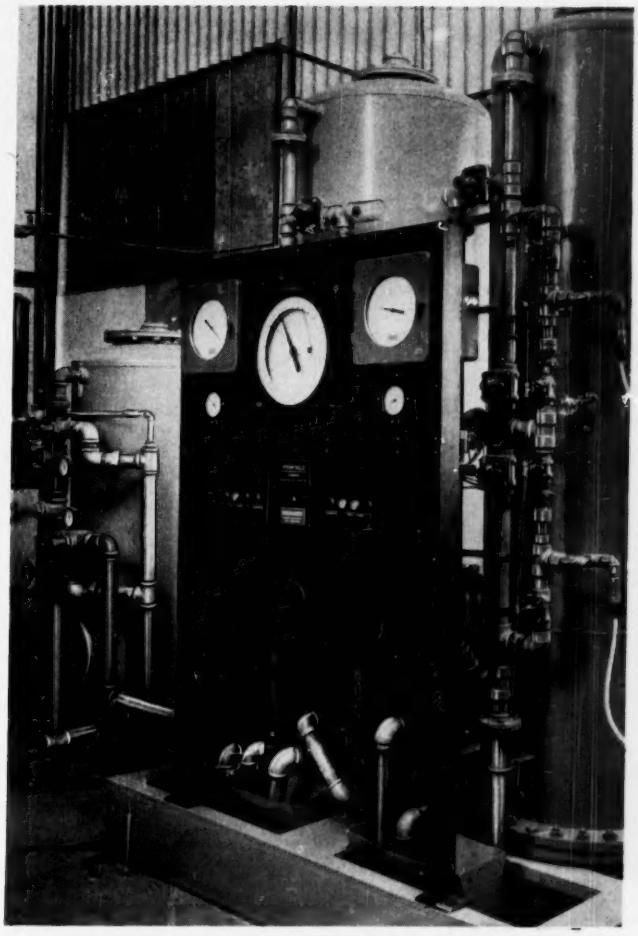

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cipally in gas-treating plants where large amounts of hydrogen sulfide are present.

The problem is ordinarily handled by chemical methods. Composition of the components which promote development of atomic hydrogen are slightly changed and rendered innocuous, or a sacrificial liner can be used.

Galvanic Corrosion — Here is the preferential corrosion of a metal in an electrolyte when potential differences exist between the metal and some other substance. The corrosion occurs on the surface which is most anodic.

The greatest source of trouble from galvanic corrosion is in underground piping and the lower surfaces of storage tanks. In these spots, different soils set up electrical potential differences which create selective corrosion of the steel. This problem is handled by wrapping the pipe with asphaltic materials or cathodic protection. Sometimes both are required. Tankage should be designed with good drainage to prevent accumulation of water on the under side. Also watch for situations where different metals come into contact in an electrolyte.

Intergranular Corrosion—Actually, intergranular corrosion of sensitized austenitic stainless steel is a form of galvanic attack at the grain boundaries. Sensitization is created when stainless steel of the 18 Cr-8 Ni type is subjected to temperatures between 800 and 1,600F. This produces an intergranular chromium carbide precipitate which depletes the adjacent grain boundary area of chromium. Subsequently when such sensitized material comes in contact with certain electrolytes, an attack occurs preferentially along the grain boundaries depleted of chromium.

This phenomenon is well known in the chemical industry, and for its prevention the stabilized grades, Types 321, 347 or 304L, are required in critical services. Type 304 is used only in non-critical services or in furnace piping where the metal is not exposed to aqueous environments. In the latter case, care is taken during shutdown periods that the temperature in the furnace does not drop below the dew point. Failures of 304 in this service by intergranular corrosion have been caused by condensed flue gases containing SO_2.

Groove Corrosion—A type of galvanic corrosion which preferentially attacks heat-affected areas of steel equipment when exposed to certain corrosive media is known as groove corrosion. When steel is heated as in welding, a narrow band of a spheroidized structure is formed adjacent to the weld. In certain electrolytes this zone is anodic to the parent metal and a high localized rate of attack occurs. Groove corrosion has been noted in plants handling strong sulfuric acid, strong caustic, furfural and hot phenol.

The remedy is to normalize the parts after welding. This treatment reabsorbs the sensitive area and the entire piece is uniform in structure.

Dezincification—Another type of galvanic corrosion, dezincification, occurs in brasses containing more than 15% zinc. In the presence of an electrolyte dezincification is created by the alloy going into solution followed by a redeposition of porous copper having very little mechanical strength.

There are three types of dezincification: intergranular, layer and plug with the latter being the most serious.

The most common occurrence of this phenomenon is in brass condenser tubes when exposed to water services. The problem is largely under control by the addition of inhibitors such as arsenic, phosphorus or antimony in small amounts to admiralty brass. Cooling tower hardware is subject to this attack and care should be taken to install red brass or silicon bronze, which are not subject to dezincification.

▶ **Corrosion Plus Stress**—When under the combined influence of a sufficient residual tensile stress and exposure to a critical corrosive environment, almost any metal can be made to fail by stress corrosion cracking.

Corrosion as measured by loss in dimensions is usually negligible. Chloride solutions are the worst offenders in promoting stress corrosion cracking of stainless steels, and many failures involving chloride compounds have been reported to the chemical industry. Caustic solutions and nitrates will crack steel if concentrations and temperatures are critical. Mercury and ammonia will readily crack strained brass.

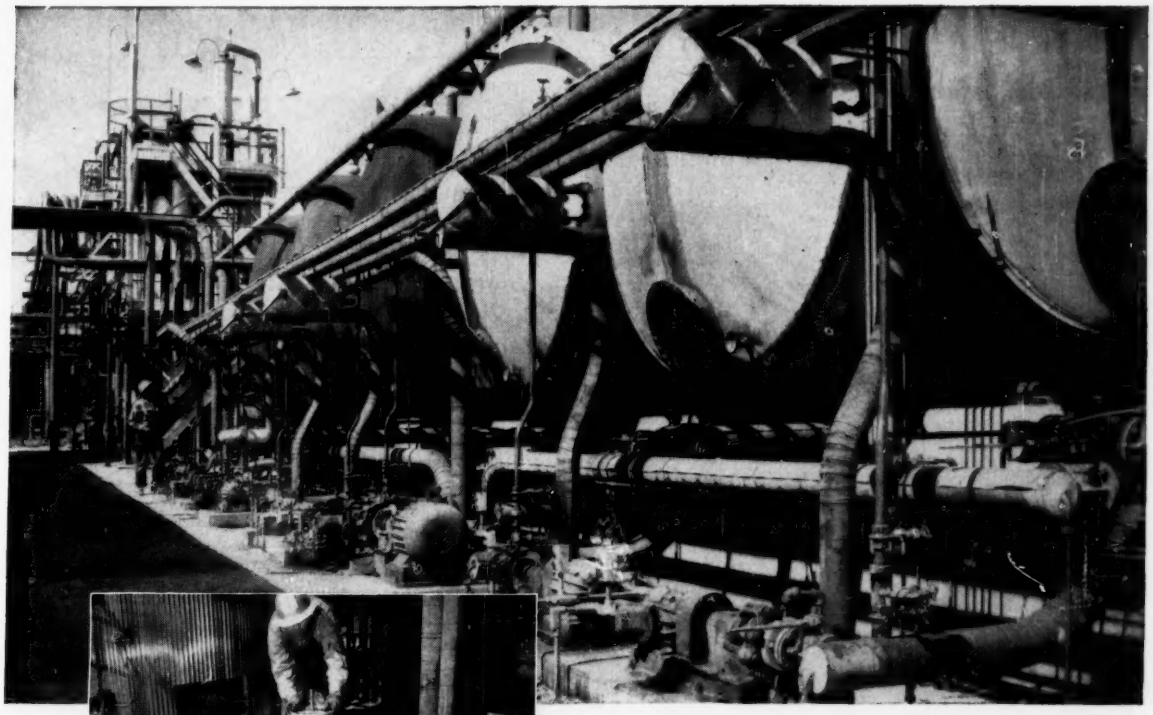
The mechanism of stress corrosion cracking involves a very complicated sequence of corrosion and fracture. It has been shown that fine pitting is needed to start the activity. The pit initiates a mechanical crack at right angle to the maximum strain. Further progress is then a process alternating between corrosion and mechanical cracking until the material fails completely.

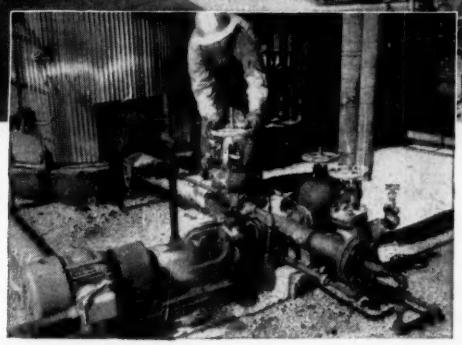
To avoid stress corrosion cracking, present practices are to stress relieve the equipment by thermal treatment or to use a material which is not subject to cracking in the particular environment. If more were known about the particular concentration and temperatures which will cause cracking, suitable charts could possibly be prepared to better specify fabrication procedures. The amount of work required for the preparation of such charts for the many corrosive mixtures used in the chemical industry is so vast that at the present time none have been prepared.

Data obtained from exposure of stressed specimens to the pilot plant streams are used as criteria for specifying stress relieving treatments. One chemical which is widely used is sodium hydroxide. Due to the wide use of this chemical, much experience has been gained and predictions can be made as to the critical area where stress corrosion cracking, known as caustic embrittlement, will occur. A chart showing this region is shown on p. 134.

Corrosion fatigue may be encountered when equipment such as condenser tubes are vibrating in the presence of a pitting type of corrosion. A crack starts at the base of a small pit and proceeds in a straight path similar to ordinary fatigue. Vibration prevention or use of a more resistant metal is the usual cure.

Based on a paper given at the Western Metals Congress, ASM, in Los Angeles, Mar. 1959.





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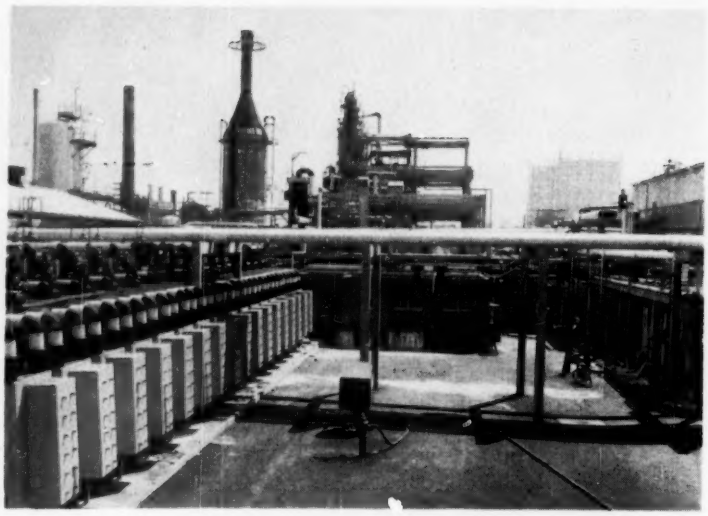


Atlantic Gets "World's Largest" MEK Dewaxing Unit

Atlantic Refining Co.'s Philadelphia, Pa., refinery now boasts a huge methyl ethyl ketone solvent dewaxing plant for manufacture of 265 tons of paraffin waxes per day. The $18-million unit was engineered and built by Badger Mfg. Co.; photo above shows scraper-chillers on the left and filter house on the right.

J. R. Simplot Co., Boise, Idaho, has construction under way on a new $2-million clay and silica refining plant at Bovill, Idaho, operating on a kaolin clay feed material. Clay products will go to paper and ceramic industries while silica will go to glass manufacturers. Firm will also spend "several hundred thousand dollars" expanding its starch plant at Heyburn, Idaho.

Atomic Energy Commission has signed contract with Globe Mining Co., subsidiary of Union Carbide, calling for erection of a $3-million, 492-ton/day uranium mill in Wyoming's Gas Hills District. New mill will employ a form of the Infilco resin-in-pulp process (*Chem. Eng.*, May 4, 1959, pp. 52-54).

U. S. Phosphoric Products is planning to build a multi-million-dollar ammonia plant at Tampa, Fla. Engineering studies are currently under way to determine size of facility required.

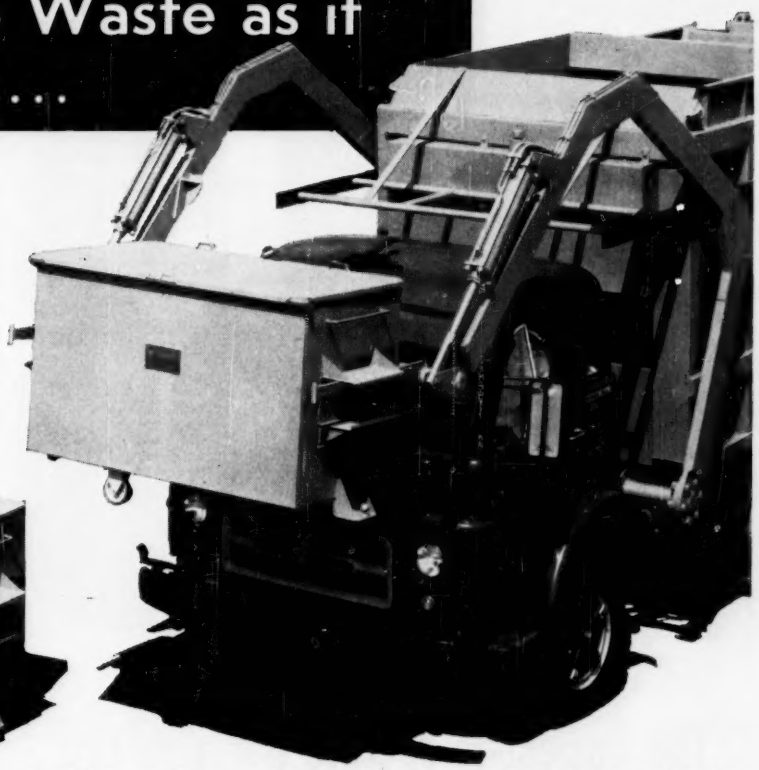
Du Pont's Film Dept. recently opened a new 50-million-lb./yr. cellophane plant at Tecumseh, Kan., near Topeka. A company spokesman cited the "favorable long-range business climate" as reason for picking the Tecumseh site.

Union Carbide's Linde division is getting construction started on a new liquid hydrogen facility at Torrance, Calif., to supply up to 3.3 million lb./yr. to the National Aeronautics and Space Administration. Firm notes that although contract calls for a plant output of around 5 tons/day, facility

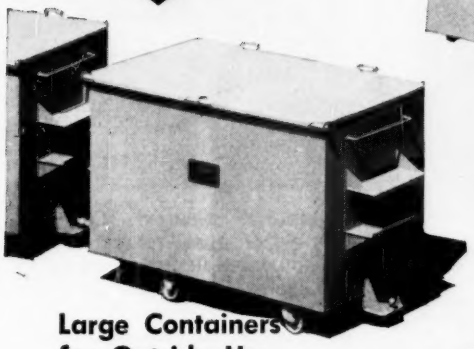
cut disposal costs by two-thirds...

Containerize Waste as it Accumulates...

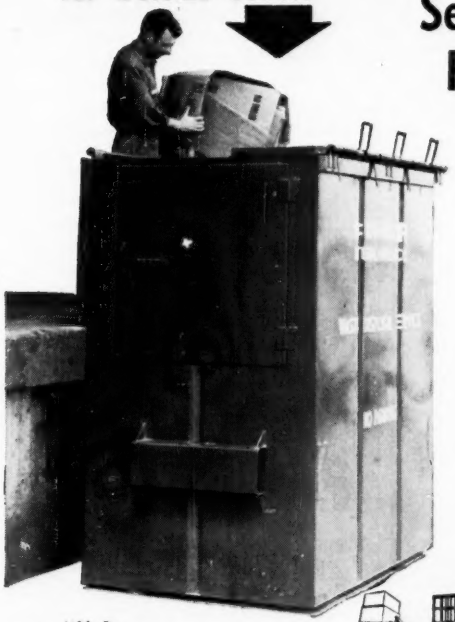
Patents Pending



Small Tracking Containers for Indoor Use...



Large Containers for Outside Use...



Mfd. By DEMPSTER BROTHERS Inc.

Self-Loading DEMPSTER-DUMPMASTER Handles 6 Sizes of Containers...

If you're using boxes, bins, cans or carts to handle or store big-volume waste and refuse, you can reduce costs by more than two-thirds with the new DEMPSTER-DUMPMASTER System of waste storage and collection.

One Dumpmaster serves any number of detachable metal containers placed at waste accumulation points. Making its rounds, the Dumpmaster picks up each container, in turn, empties the contents into its packer body and compresses the material to a fraction of its former volume assuring big pay loads on every trip to the disposal area.

The DEMPSTER-DUMPMASTER is economical! One man operation. It's safe! Clearance lifting arms never pass the cab windows, can't injure operator. Containers can be used indoors or outdoors, on ground, below grade or on a dock.

This system is also available on a monthly fee basis through a nearby DEMPSTER-DUMPMASTER equipped private hauler, (name furnished on request).

WRITE TODAY FOR FREE BROCHURE

DEMPSTER DUMPSTER® SYSTEMS

Dept. CE-6 DEMPSTER BROTHERS, Knoxville 17, Tennessee

NEW FROM KIDDE!

2½-gallon pressurized water

2½-gallon anti-freeze (loaded stream)

The easiest-to-operate portable fire extinguishers on the market today!

Here, for the first time, is a practical, sensible design for pressurized water and loaded stream extinguishers. No inverting, no bumping, no valves to turn, no pins to pull (safety lock automatically releases when nozzle removed).

These two new stainless steel Kidde portables feature simple, one-two operation—just aim at fire and push the button. Notice the way the hose is stored, safely out of the way. Notice the wide-open handle—to insure fast action even in gloved hands. Notice the dust-and-waterproof pressure gauges—which show at a glance whether the units are fully charged. All of the features—plus the slim design and light weight of these Kidde portables—make them the easiest-to-store, easiest-to-carry, easiest-to-operate portables on the market today.

Approved by Underwriters' Laboratories. Available in pressurized water for fires in ordinary combustibles, or anti-freeze loaded stream for fires in ordinary combustibles and flammable liquids. For more information, write to Kidde today.

Kidde

Walter Kidde & Company, Inc.
629 Main St., Belleville 9, N. J.
Walter Kidde & Company of Canada Ltd.,
Montreal—Toronto—Vancouver

The words 'Kidde', 'Lux', 'Lux-O-Matic', 'Fyre-Freez' and the Kidde seal are trademarks of Walter Kidde & Company, Inc.

FIRMS . . .

will have capacity "in excess of this volume."

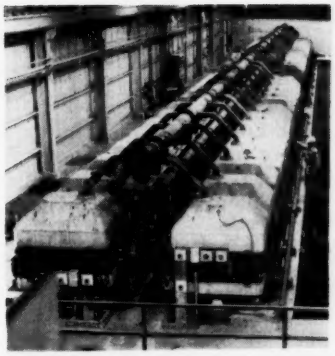
Dow Chemical announces plans to build a polyethylene film plant near Fresno, Calif., expected to be completed early in 1960. Only clue to size is the initial employment figure which is set at about 100.

Stauffer Chemical Co. has shipped the first carload of aluminum fluoride from firm's Nyotex Div.'s plant at Houston, Tex. Utilizing a "novel process" developed by Stauffer, new facility is rated at 10,000 tons/yr. Aluminum fluoride is used as electrolytic bath material by the aluminum industry.

Ketona Chemical Corp., jointly owned by Alabama By-Products Co. and Hercules Powder Co., is now in commercial production of prilled ammonium nitrate at its Birmingham, Ala., plant. Facility was the first in the country ever to produce ammonia entirely from coke oven gas.

Davison Chemical has installed facilities at its Curtis Bay Works in Baltimore, Md., for continuous production of 100 tons/hr. of superphosphate. Facility was designed by A. J. Sackett & Sons, Baltimore.

HEF, Inc., jointly owned by Foote Mineral and Hooker Chemical, is now in production of ammonium perchlorate at its new Columbus, Miss., plant. Initial capacity is about 4 million lb./yr.



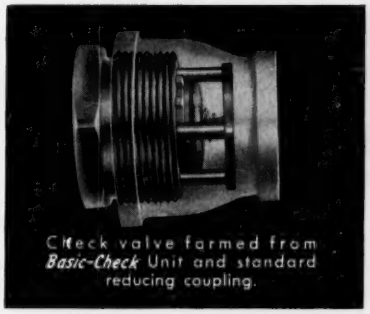
Kaiser Aluminum & Chemical has gone into production of alumina at its new $70-million plant at Gramercy, La., with the completion of a 5,350-ft. brine well for production of chlorine and caustic soda. Hooker cells shown above are part of facility that turns out 114 tons/day caustic for alumina manufacture; chlorine is sold to other chemical makers.

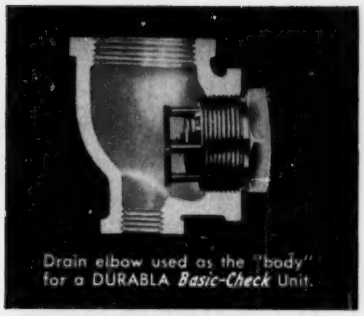
Pennsalt Chemicals Corp. has a $2-million expansion program under way at its Portland, Ore., plant to step up production of ammonium perchlorate, started at the Portland site last year. Exact capacity boost was not revealed, but it was placed at "several thousand tons per year." Sodium chlorate facilities are also being expanded by about 25%.

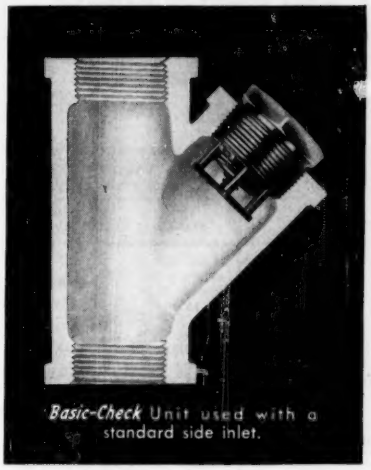
Standard Oil of California is getting the major units of its new $33-million catalytic cracker complex into production at Richmond, Calif. Project is designed to shift production away from heavy fuel oil towards increased motor oil output.

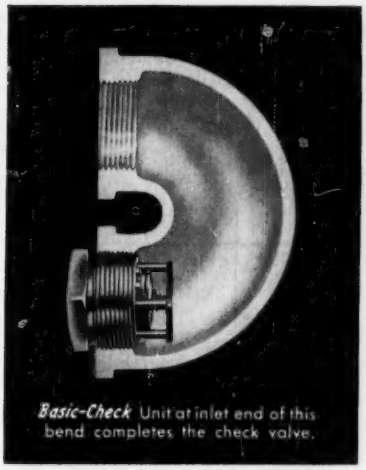
Crown Zellerbach is now in production at its Orange, Tex., polyethylene film plant with addition of two new production lines scheduled for July and August. Crystalline polyethylene is piped to the facility from Spencer Chemical's adjacent plant.

Filon Plastics Corp. has broken ground in Hawthorne, Calif., for construction of a $1-million plant for production of









How you can "make" a check valve to meet any emergency

Just take a DURABLA *Basic-Check* Unit . . . combine it with a standard pipe fitting . . . and you have a complete check valve that's perfect for practically any service. Keep a few *Basic-Check* Units on hand and you are prepared for any emergency.

Because it will operate in any position, the DURABLA *Basic-Check* Unit can be installed without changing existing lines. Made of stainless steel, they'll handle almost any liquid, gas or air . . . over a broad range of pressure-temperature ratings.

DURABLA *Basic-Check* Units are versatile, dependable, efficient and inexpensive. They come in seven standard line sizes, from ⅜" to 2". Also available: DURABLA Reducing Couplings of stainless steel.

Ask for a copy of Bulletin CE 69

DURABLA MANUFACTURING COMPANY
114 Liberty Street, New York 6, New York

DURABLA®

DM-32

ACE Plastic Pipe

85 to 100% of your corrosion-resistant piping needs now available from 1 source

- CHOICE OF 9 DIFFERENT TYPES
- THE NEWEST OF MATERIALS
- BACKED BY 100 YEARS OF EXPERIENCE

HOW TO SELECT THE RIGHT PIPE

	TYPE	SIZES	PROPERTIES	VALVES	ASK FOR BULLETIN
1	ACE-ITE	Threaded Pipe ½ to 6"	General purpose rubber-plastic blend. Tough, impact resistant, economical. Handles most common chemicals to 170°F.	Diaphragm valves with Ace-Ite body, ½ to 2"	80-A
2	RUBBER-LINED STEEL	Flanged Pipe 1½ to 24" and up	Strength of steel, resistance of hard rubber. Soft-rubber inter-layer aids shock-resistance. Finest for alkalis, most inorganic acids, many organic acids, all salts.	Rubber-lined C.I. Gate, Darling Gate & Check Valves to 24". Diaphragm Valves to 6"	CE-52
3	ACE TEMPRON	Threaded Pipe 1 to 8"	Best anywhere for hot inorganic chemicals, acids, etc. to 260-275°F. Also wide variety of organics. Excellent rigidity.	— —	96-A
4	ACE RIVICLOR	Threaded Pipe ½ to 4"	Rigid PVC. Excellent aging. Good cold impact strength. Not affected by most inorganic acids and alkalis. Also good for many organics.	Diaphragm valves with Riviclor body ½ to 2"	CE-56
5	ACE PARIAN	Threaded Pipe ½ to 2"	Odorless, tasteless, rigid polyethylene, best for sub-zero uses. Best resistance of any plastic at room temp. except to acetic acid.	Diaphragm valves with Parian body, ½ to 2"	351
6	ACE HARD RUBBER	Threaded ½ to 4" Flanged 1½ to 8"	The oldest, still tops. Extreme resistance to alkalis, inorganic acids, many organics, all salts. Ideal for chlorine, fluorine. Widest range of fittings.	Rubber-lined or plastic valves above. Also many plug valves, bibb cocks, etc.	CE-51
7	ACE SARAN	Threaded Pipe ½ to 4" Tubing ⅛ to 1¼"	Odorless, tasteless, general-purpose. Strong, takes high pressures. Not affected by most inorganic acids and alkalis; resistant to most organics.	Diaphragm Valve with Saran body ½ to 2". Also Saran-lined diaphragm valves to 6" and up	CE-58
8	ACE-FLEX	Flexible Tubing ⅛ to 1¼"	General-purpose transparent flexible tubing. Non-toxic, odorless, tasteless. Can steam sterilize. Excellent for chemicals.	Ace hard rubber plug valves, bibb cocks, etc.	66
9	SUPPLEX	Flexible Pipe ½ to 2"	Non-toxic flexible polyethylene pipe. Ideal for water distribution lines, drain lines, jet wells, etc. Resistance similar to Parian. Uses insert type fittings.	Diaphragm valves with Parian body, ½ to 2"	CE-57

ACE Saran, Supplex, Ace-Ite and Riviclor are approved by The National Sanitation Foundation for drinking water.

RUBBER AND PLASTIC LINED TANKS, PUMPS, MOLDED PARTS, ETC., FOR ANY NEED

AMERICAN HARD RUBBER COMPANY

Division of Amerace Corporation

ACE ROAD • BUTLER, NEW JERSEY

SEE ACE EQUIPMENT IN CHEMICAL ENGINEERING CATALOG

FIRMS . . .

glass-fiber-reinforced plastic building panels. Facility will be ready for occupancy by year's end.

Atomic Energy of Canada, Ltd., has awarded Badger Mfg. Co. a contract for design, fabrication and construction of a heavy water fractional distillation plant to be built at Chalk River, Ont. When completed late in 1959, plant will reconcentrate heavy water that has been downgraded by light water contamination.

Universal Oil Products has formed a new chemical products development department as part of the firm's efforts to develop new chemical products and to enlarge its present product line for sale to petroleum and related industries.

Parke, Davis & Co. has established a Commercial Development Div. to undertake economic and market research as well as product planning. Move, says the company, will provide for "transition of products from early stages of development to their introduction on the market."

National Gypsum Co. has completed its acquisition of Huron Portland Cement Co. through an exchange of stock. Huron will continue to operate under its own name and will keep its staff and facilities.

Reheis Co., producer of aluminum salts for cosmetic and pharmaceutical industries, has acquired the Tech-Chemical Corp., producer of liver preparations and other biologicals. Purchase includes Tech-Chemical's Stamford, Conn., refining plant and its Montevideo, Uruguay, bulk processing plant.

CALENDAR

Gordon Research Conference: Polymers, Colby Junior College.
July 6-10 New London, N. H.

Society of Chemical Industry, 78th annual meeting.
July 6-11 Glasgow, Scotland

Foundation for Instrumentation Education-American Institute of Chemical Engineers, summer conference: process dynamics, Case Inst. of Technology.
July 6-24 Cleveland, Ohio

Gordon Research Conference: Organic Reactions and Processes, New Hampton School.
July 13-17 New Hampton, N. H.

Chemical Society of London, symposium on fluorine chemistry.
July 15-17 Birmingham, England

Gordon Research Conference: Corrosion, Colby Junior College.
July 20-24 New London, N. H.

Gordon Research Conference: Radiation Chemistry, New Hampton School.
July 27-31 New Hampton, N. H.

Gordon Research Conference: Organic Coatings, Colby Junior College.
July 27-31 New London, N. H.

National Soybean Processors Assn.-American Soybean Assn., joint annual meeting, Sheraton-Jefferson Hotel.
Aug. 10-12 St. Louis, Mo.

American-Pharmaceutical Assn., annual meeting. Netherland-Hilton Hotel.
Aug. 16-21 Cincinnati, Ohio

Gordon Research Conference: Chemistry and Physics of Metals, Kimball Union Academy.
Aug. 17-21 Meriden, N. H.

Technical Assn. of the Pulp and Paper Industry, 10th Testing Conference, Multnomah Hotel.
Aug. 18-21 Portland, Ore.

International Union of Pure and Applied Chemistry, symposium: Chemical Thermodynamics.
Aug. 20-25 Wattens, Austria

American Rocket Society, symposium: Gas Dynamics, Northwestern University.
Aug. 24-26 Evanston, Ill.

Gordon Research Conference: Instrumentation, Colby Junior College.
Aug. 24-28 New London, N. H.

Chemical Institute of Canada, Physical Chemistry Div. meeting, McMaster University.
Aug. 30-Sept. 1 Hamilton, Ont.

International Union of Pure and Applied Chemistry, symposium: Thermodynamics and Thermochemistry.
Aug. 30-Sept. 6 Munich, Germany

Assn. for Computing Machinery, national meeting, Mass. Institute of Technology.
Sept. 1-3 Cambridge, Mass.

Life in these excited states...

Corrosion is full of surprises

Out-guessing corrosion has been our business for 100 years. We now make 8 types of chemical resistant pipe . . . with valves, pumps, and tanks to match . . . and pretty well know what to expect with them. If anything, our advice is on the *safe* side. Please consult us with *any* problem.

RIVICLOR *for ageless strength*

All-purpose rigid PVC. Sched. 40, 80 & 120, ½ to 4". Threaded or socket-weld fittings. Valves ½ to 2". NSF-approved. *Bul. CE-56.*

NEW ACE Gear Pump

Improved design . . . now 12 gpm. All wetted parts acid-resistant, wear-resistant Ace hard rubber. Finest available. *Bul. CE-55.*

SUPPLEX *tops in economy*

Flexible poly pipe, ideal for water lines, drains, underground pipe or conduit. Sizes ½ to 2", long coils, NSF-approved for drinking water. *Bul. CE-57.*

VALVE HEADQUARTERS

World's best chemical valves . . . at moderate prices. All-plastic, rubber-lined, or all-hard-rubber. ⅛" pet cocks to 24" gate valves.

ACE processing equipment of rubber and plastics

AMERICAN HARD RUBBER COMPANY
DIVISION OF AMERACE CORPORATION
Ace Road • Butler, New Jersey

ADAMS FACT FILE #2

PLANT AIR

Moisture Chief Cause of Trouble . . .

Every company today is looking for ways to offset the increased costs of labor, material, equipment and services. At a gasoline station you expect "Free Air", but in industry it is a major expense. Perhaps in your own plant, for an investment in a few minor compressed air system alterations, significant savings are possible.

Water, sludge, rust, oil and dirt in compressed air systems are prime causes of maintenance and production down-time. Water vapor condensing in air lines tends to corrode the piping. Also, water present in the piping may freeze during winter, causing serious reduction of compressed air supply. Such restrictions are often difficult to locate and thaw. This same line moisture may emulsify lube oil destroying its lubricating value and the resultant mixture has high fouling characteristics. Frequently, ice will form within the tool itself since expanding air cools the moisture . . . tool efficiency will be seriously affected.

Some of the Other Problems Created By Wet Compressed Air . . .

Wet compressed air is not only a construction and production tool problem. Faulty paint jobs, contaminated chemical and food products can often be traced to moisture laden compressed air. Waterhammer, unequal pipeline thermal expansion and line leaks also result from collected moisture. In addition, air lost through traps, and in blow-down of compressed air lines provide no useful work . . . represent a sizeable power loss.

You Can Lick Compressed Air Moisture Problem . . .

All of these hidden costs can be virtually eliminated by the installation of an Adams Aftercooler and Cyclone Separator between the compressor and receiver tank. By cooling discharge air to within 10° F. of cooling water temperature — guaranteed with Adams standard Aftercoolers — the moisture can be removed at the separator. Pressure loss is less than one-half pound on these units including the separator. In severe cases, moisture removal of over 90 per cent can be obtained by cooling the air with Adams 2° Aftercooler to within 2° F. of water temperature.

Air Filter for Final Protection at Point of Use . . .

As an added safeguard for expensive tools and equipment, an Adams Poro-Stone Air Filter should be installed just before the air is used. These filters remove all solid material picked up by the air stream. With an Adams Aftercooler, Cyclone Separator and Air Filters clean, dry, trouble-free air is supplied to your production tools. You get continuous service with minimum maintenance.

For further information on how the complete line of Adams air equipment can solve your compressed air problems, write today for your free copy of Bulletin No. 712 on Aftercoolers and Bulletin No. 117 on Poro-Stone Air Filters from the R. P. Adams Company, Inc., 207 East Park Drive, Buffalo 17, New York.

(*Continued from p. 76*)

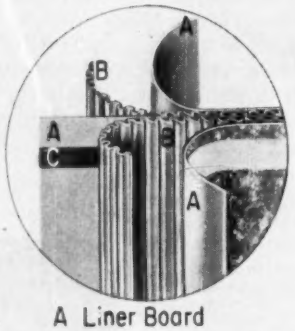
furnished with high and low viscosity alarms. Basic measuring elements operate on the principle of determining the time required for a piston to fall a given distance through the fluid being monitored.—**Norcross Corp., Newton, Mass. 76E**

Silicon Rectifiers

Combine small size with good regulation.

A new series of light-weight, high-power silicon rectifiers is available in nine peak-inverse voltage ratings ranging from 50 to 500 v. The hermetically sealed cells can be used to provide up to 70 a. of forward direct current.

Weighing less than 3 oz., the new units can operate at temperatures up to 190 C. junction. Maximum reverse current is 30 ma.—**Westinghouse Electric Corp., Pittsburgh, Pa. 144A**

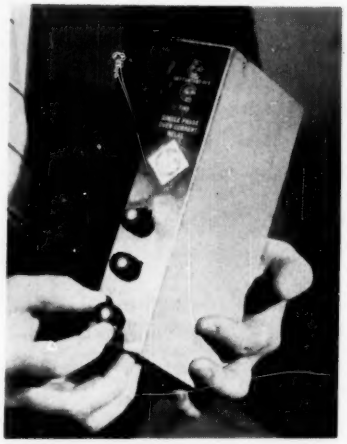


Car Liner

Material upgrades walls of shipping cars.

A new car liner called Steel-Corr, introduced to shippers and railroads this month, is an upgrading material that eliminates the need to shop cars with major lining damage. Comprised of three layers of liner board and two corrugated mediums with imbedded ¾-in. steel straps, Steel-Corr is bonded with a special adhesive which, the company says, adds moisture protection.

Each kit contains four corner posts, four end panels, and 16 side panels—enough for a complete car. It can be easily installed by two men in less than an hour with no special tools.—**Ford Carliner Div., Omaha, Neb. 144B**



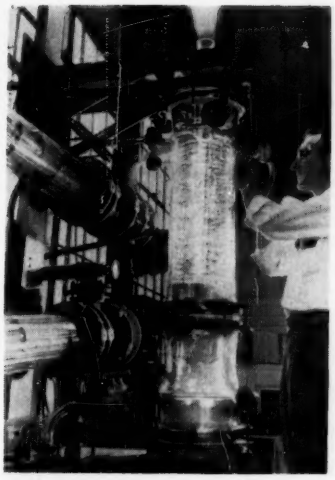
Overcurrent Relay

Completely static protective relay introduced.

Static protective relays for industrial switchgear applications will be available this summer with Allis-Chalmers switchgear equipment. A-C claims that the new relay is the first major departure from the mechanical induction-disk design introduced about 50 years ago.

Basic circuitry incorporates various kinds of semiconductors. There are no moving parts. Three sets of external controls located at the front of each unit adjust calibration and setting. Size of the new unit is one-third that of its predecessors.

According to A-C, extensive temperature range and life tests have proved that reliability of the static relay is superior to the old, mechanical types.—**Allis-Chalmers Mfg. Co., Milwaukee, Wis. 144C**

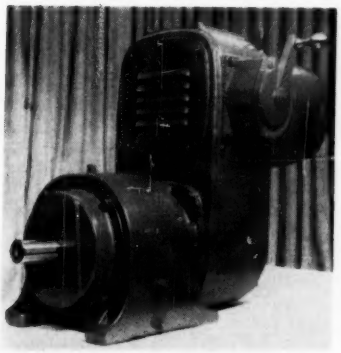


Glass Heat Exchangers

English-made units being distributed in U.S.

New, coil-type glass heat exchangers, manufactured by Q.V.F. Ltd., of England, are now being distributed in the U.S. by Corning Glass Works. The compact, modular units consist of a glass shell that surrounds single glass-tubing coil.

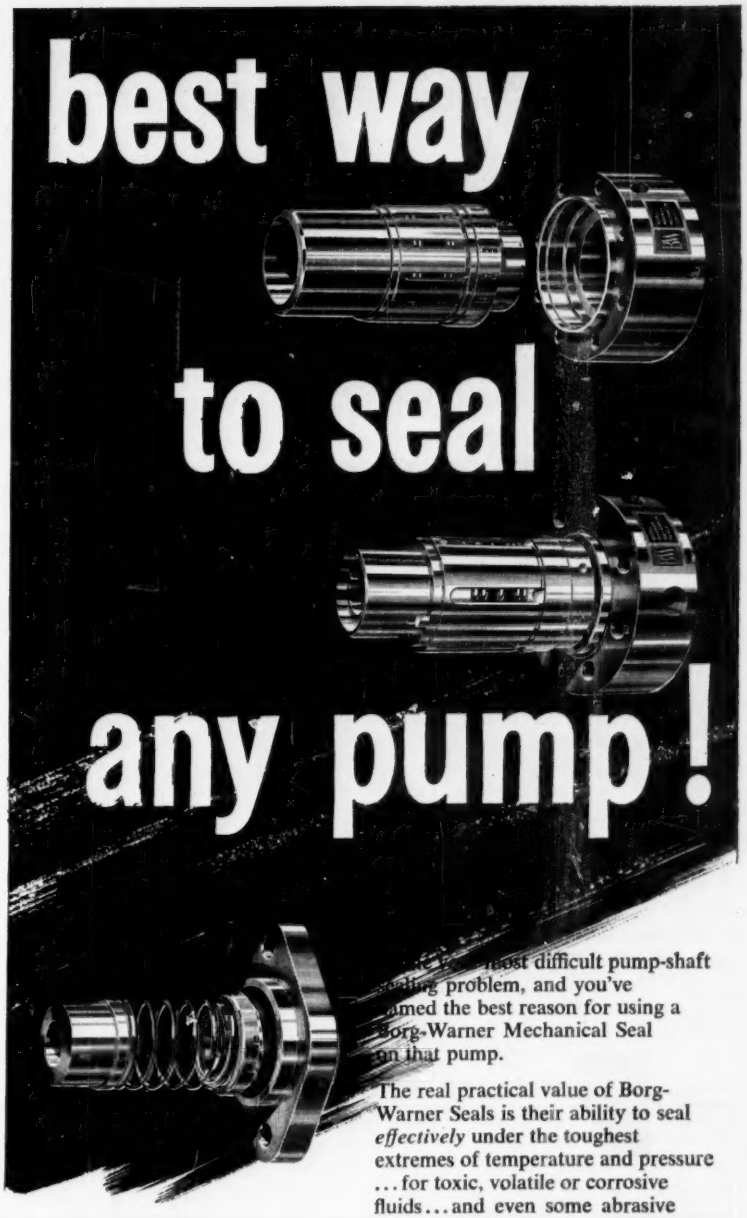
Sizes range from 2½ to 60 sq. ft. The 60-sq. ft. model takes up only 4.4 cu. ft. of plant space, and weighs approximately 94 lb. —**Corning Glass Works, Corning, N. Y.** 145A



Adjustable Drives

Company offers its first models of new line.

A new line of adjustable-speed drives, which operate on the principle of V-belt-connection adjustable-pitch pulleys, are available in a wide



...most difficult pump-shaft ...ing problem, and you've ...med the best reason for using a Borg-Warner Mechanical Seal on that pump.

The real practical value of Borg-Warner Seals is their ability to seal *effectively* under the toughest extremes of temperature and pressure ... for toxic, volatile or corrosive fluids ... and even some abrasive liquids. *Result*—less down time, elimination of expensive stuffingbox maintenance, and savings of the pumped fluid.

Borg-Warner Mechanical Seals

NOW AVAILABLE—a new file folder of Borg-Warner Mechanical Seal designs shows some of the many types and applications possible for pumps, mixers, autoclaves and for special rotating shaft problems. Send for your copy today—there's no obligation!

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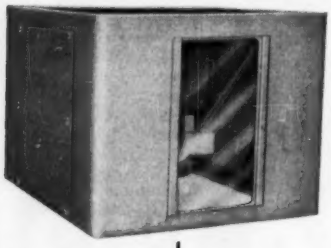
Borg-Warner® Mechanical Seals

P. O. Box 2017, Terminal Annex, Los Angeles 54, California

NOW "Add-To-Design" PAVES THE WAY TO SIMPLER FEEDER INSTALLATIONS



The W&T Series A-728 Dry Chemical Feeder forms a base for a complete feeder installation. Standard components are available —designed for use with the Feeder. For instance, the A-728 permits

. . . use of hoppers in standard lengths and sizes—ending your hoppering problems.

. . . choice of solution tanks—corrosion resistant and tight for the chemicals you use.

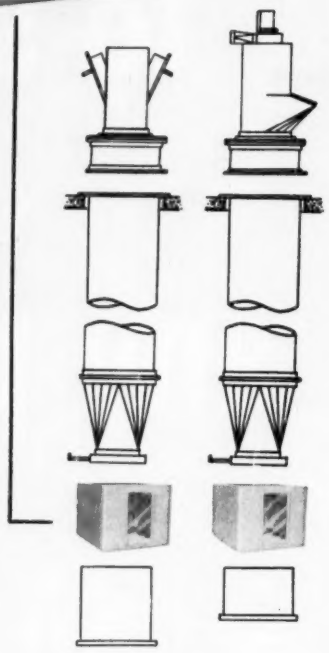
. . . direct feeder mounting of standard dust collectors, bag loaders, screens—eliminating extra structural supports.

. . . use of overhead supports—to eliminate your floor stress problems.

This means you use standard components to build your own custom installation without special design . . . saves you time and money.

■ ■ ■ ■

Write us for information to help you build your own feeder installation—easily and simply. Address Dept. MV-3.2/.



WALLACE & TIERNAN INCORPORATED
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

W&T Chemical Solution Feeders furnish

ACCURATE...RELIABLE...FULL STRENGTH

hypochlorite dosage for bacterial control of small water supplies.

Be safe; ask for them; Write Dept. L-2.29

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

range of outputs and speed ratios. Known as Polydyne drives, the units feature simple belt changing, smooth operation and compact appearance.

Polydyne drives come in sizes from ¼ through 25 hp., with output speeds to over 4,000 rpm. Standard speed variations are 2, 3, 4 and 5 to 1. Accessories include remote mechanical, electric and pneumatic controls. —**General Electric Co., Schenectady, N. Y.** **145B**

BRIEFS

Redesigned valve for temperature control features a new, removable thermal system that allows field changing of control ranges without affecting valve stroke. Designed to control temperatures from 45 to 450 F., these sliding-gate valves are available from stock in ¼- to 2-in. sizes. Materials of construction include cast iron, bronze, ductile iron, aluminum or Monel metal.—**OPW Jordan, Cincinnati, Ohio** **146A**

Flow-control valve with built-in pneumatic or hydraulic actuator comes at a price that is competitive with standard hand-operated valves. Claimed to be completely maintenance-free, the valve is capable of either two-position or modulating remote control.—**D. M. Connor & Co., Metuchen, N. J.** **146B**

Spinneret heater developed especially for nylon work is claimed to have extremely long life and high efficiency. Terminals can be bent by the customer; armored flexible extensions are available at extra cost. Enclosed in a stainless steel shell, the tubular-type heater comes in several different wattages and voltages.—**Thermal, Inc., Franklin Park, Ill.** **146C**

Air sampler intended for work with dusts, fumes and gases features high mobility for easy application at various plant sites. The 4-cfm. air mover is actuated by graphite-ringed pistons driven by

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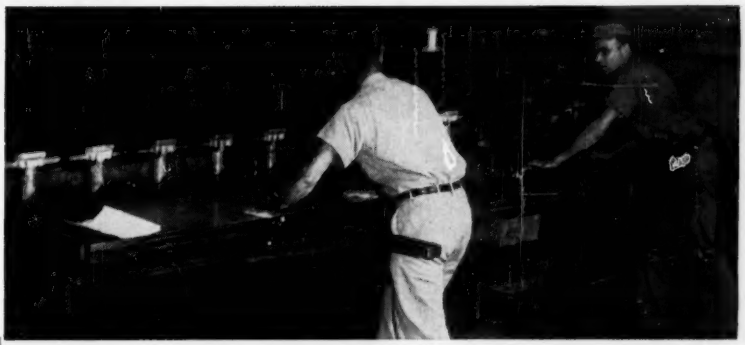

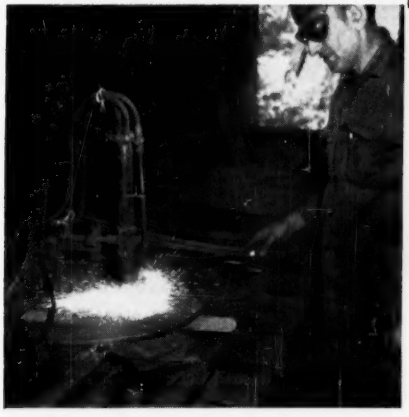

• Besides keeping our warehouses fully stocked with all forms of Carpenter Stainless No. 20 and 20Cb, we maintain fast, modern facilities to make up and speed your orders to you . . . no matter what your deadline. *Our service teams are geared to handle your most urgent delivery needs.*

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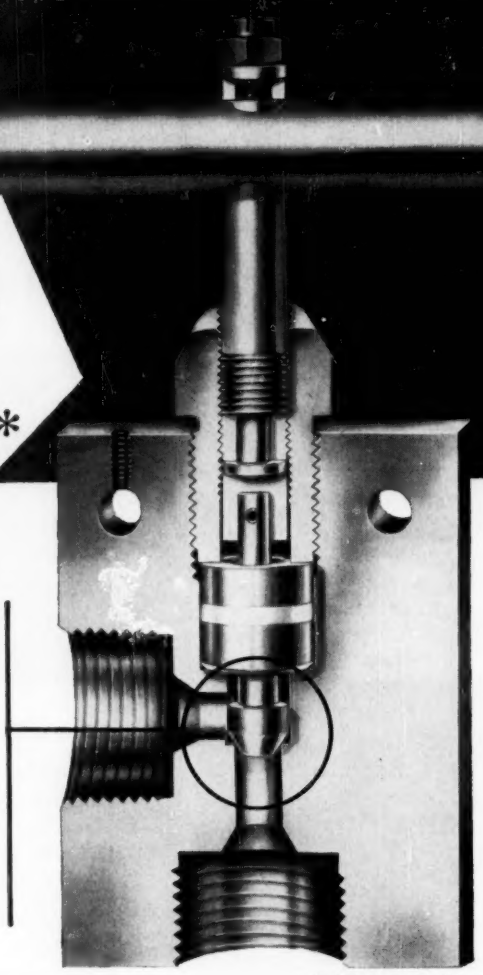

Only This Unique Design Gives You All These Advantages:

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- **Pre-Loading Construction** — assures operating without "slop"
- **Stem Does Not Rotate Against Seat** — No scoring of either stem or seat
- **Choice Of Lower Stem Materials** — Stainless, hastelloy, monel, etc. (standard stem 316 s.s.)

This major improvement in floating-stem valves gives you operating advantages available in no other valve. When you operate this valve, you get positive stem action immediately . . . no "backlash", no "play", no loss of "feel", and no scoring because the floating stem does not rotate against the seat. You have a choice of lower stem materials such as stainless steel, hastelloy, titanium, monel, etc.

And these new floating-stem valves give you the same finger-tip control, the same leak-proof action characteristic of *all* AE Valves. What's more, you can install the new floating-stem in your present AE Valves—easily, quickly. Whenever corrosion or scoring is a problem, *always* specify AE Floating-Stem Valves.

*AE FLOATING-STEM VALVES are patented Pat. No. 2,887,293

For More Details On AE FLOATING- STEM VALVES, Send For Bulletin 5152-A

AUTOCLAVE ENGINEERS, INC.

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a ½-hp. motor.—**The Gelman Instrument Co., Chelsea, Mich.** 146D

Thermocouple assemblies capable of withstanding ambient temperatures of 2,000 F. plus, are designed for applications where thermocouple leads must pass through zones of extreme heat. Insulation is crys'alline magnesium oxide compacted to maximum density inside an Inconel sheath. Wire gage sizes from 15 to 28. —**Revere Corp. of America, Wallingford, Conn.** 149A

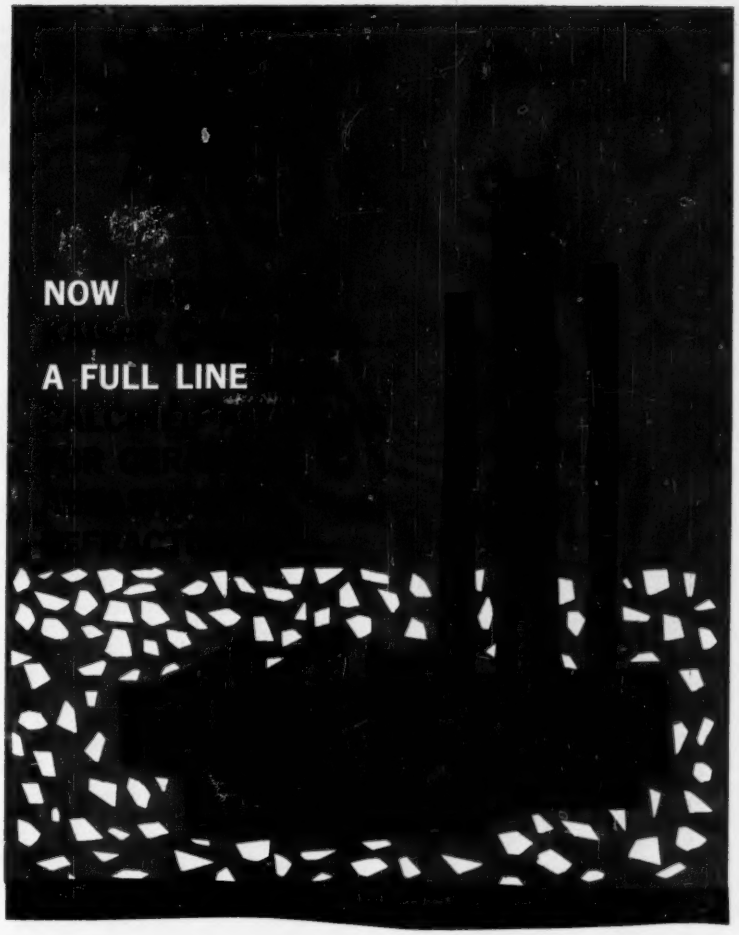
Feed pump that operates at 70 strokes/min. has a capacity up to 65 gal. every 24 hr., an operating pressure up to 125 psi. and a maximum continuous temperature rating of 100 F. Primary feature is a hydraulically balanced Teflon slack diaphragm.—**Fischer & Porter Co., Hatboro, Pa.** 149B

Flow system composed of transducers, a computer, integrater and counter can monitor or control gas or liquid flow with a long-term accuracy of 99.75%. Transducers may be located up to 1 mi. from the console. — **Computers, Inc., Houston, Texas** 149C

Equipment Cost Indexes . . .

	Sept. 1958	Dec. 1958
Industry		
Avg. of all	230.9	231.3
Process Industries		
Cement mfg.	223.3	223.7
Chemical	232.3	232.7
Clay products	217.0	217.4
Glass mfg.	219.3	219.7
Paint mfg.	222.8	223.1
Paper mfg.	223.8	224.2
Petroleum ind.	227.5	227.8
Rubber ind.	230.3	230.6
Process ind. avg.	228.6	228.8
Related Industries		
Elec. power equip.	236.0	236.4
Mining, milling	233.7	234.1
Refrigerating	260.3	260.6
Steam power	218.1	218.4

Compiled quarterly by Marshall and Stevens, Inc., of Ill., Chicago for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124—6 for method of obtaining index numbers; Feb. 23, 1959, pp. 149-50 for annual averages since 1913.



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	KC-1	KC-2	KC-10	KC-14
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TiO_2	0.002	0.002	0.002	0.002
Na_2O	0.60	0.50	0.10	0.04
Loss on ignition	0.70	0.10	0.15	0.15
Al_2O_3 (by difference)	98.658	99.36	99.5	99.6

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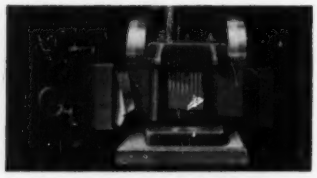
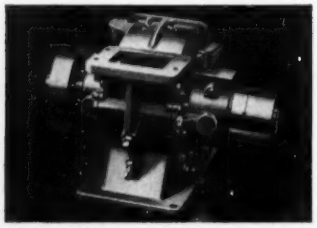
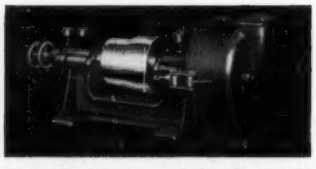


Lab Jaw Crusher: Crushes hardest rocks at ½ to ⅛ in. settings. Roll jaw action — no clogging. Feed opening 2 x 6 in. Capacity to 1900 lbs. per hr. at ½ in. setting. Instant adjustment. Manganese jaws, reversible shield.



Lab Swing-Sledge Mill: 5 x 6 in. opening takes soft, medium, tough or fibrous feed. Capacity to 1 tph. Fines regulate from 1 in. to 20 mesh. Choice of gratings, hammers (or knives).



Sample Grinder: Disc type grinders for dry, friable soft or medium materials. Three sizes — 6 in., 10 in., and 14 in. take feed as coarse as ¼ in. Produces 100 mesh fines at capacities to 200 lbs. per hr. on largest model. Regulate 10 to 100 mesh. In-operation adjustment.

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International Coverage

ADVANCES IN CATALYSIS, Vol. 9. Edited by Adalbert Farkas. Academic Press, Inc., New York. 847 pages. $16.

Reviewed by F. C. Nachod, Sterling-Winthrop Research Institute, Rensselaer, N. Y.

The present volume IX of a well established series reports the proceedings of the International Congress on Catalysis held in Philadelphia in 1956.

A comprehensive review of a compilation of 83 contributed papers submitted by 148 authors would constitute a book in itself. Thus it must suffice to outline the general areas which the symposium covered: Chemistry and physics of solid catalysts; hydrogenation and hydrogen exchange reactions; physical properties of catalysts; electronic properties and catalytic activity; homogeneous catalysis and related effects; surface chemistry and its relation to catalysis; techniques and technology of catalysis; catalytic reactions of hydrocarbons; tracer and other techniques; miscellaneous catalytic reactions; and special topics.

The truly international coverage of the meeting is borne out in that several of the articles appear in German and French.

This collection of papers undoubtedly presents a good cross-section of present-day thinking in various fields of homogeneous and heterogeneous catalysis.

For Deliberate Synthesis

ELASTICITY, PLASTICITY AND STRUCTURE OF MATTER. 2nd. ed. By R. Houwink. Dover Publications, New York. 368 pages. $2.45 (paper cover).

Reviewed by S. Reznek, Rensselaer, N. Y.

Intent of this book is to trace common laws of deformation behaviour between diverse groups of materials based on their structures, with the ultimate object of "deliberate synthesis of materials with definite desired elastic and plastic properties."

Introductory chapters are devoted to definitions of terms and general remarks on the relation of internal structure to elastic and plastic behavior. A chapter is then given to each of the subjects: Plasticity of Crystals, Amorphous Substances (Glass, Resins, Asphalt), Rubber, Cellulose and Starch, Proteins, Paints and Lacquers, Clay, Sulfur and even "Baker's Dough."

The individual chapters, with their rather copious references, serve as good, if elementary, introductions to each of the subjects covered. While it is not claimed that laws of deformation have been developed enough to cover the diverse materials treated, the text serves a useful purpose in pointing to a desired goal.

The text is a reprint of the second (1952) edition of Houwink's book, first published in 1937. Except for the chapter on rubber, there appear to be no references more recent than the date of the first edition.

BRIEFLY NOTED

ATOMIC INDUSTRY DIRECTORY OF PRODUCTS, EQUIPMENT AND SERVICES. *1959 edition. Atomic Industrial Forum, 3 E. 54 St., New York 22, N. Y.* $2.50. Gives product and service profiles of more than 220 industrial organizations active in the development and utilization of atomic energy, including manufacturers, processors, architect-engineers and constructors, consultants and suppliers of technical research services.

CORROSION AND DEPOSITS IN BOILERS AND GAS TURBINES. 198 *pp. Prepared by Battelle Memorial Institute. Order Department. American Society of Mechanical Engineers, 29 W. 39 St., New York 18, N. Y.* $6. Provides a comprehensive up-to-date survey of factors that cause destruction of boilers and gas turbines.

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HANDLE THEM WITH THESE SPECIAL "BUFFALO" FANS

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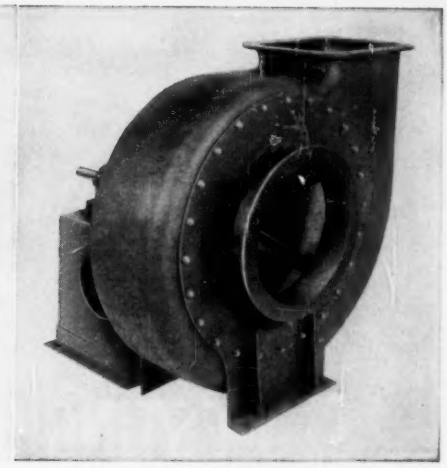

"Buffalo" Fiber Glass Fume Fan

"Buffalo" Cast Iron Exhausters are built to withstand extreme corrosive conditions in the chemical process industries. High efficiency is the result of low-turbulence air flow design. This includes heavy-duty cast iron housings and cast inlet cones with integral inlet vanes. Non-overloading characteristics are preserved despite changes in system pressure. Available with direct motor drive, separate belt drive or package unit with adjustable pitch V-belt drive and motor mounted on adjustable base rails. Write us for full information.

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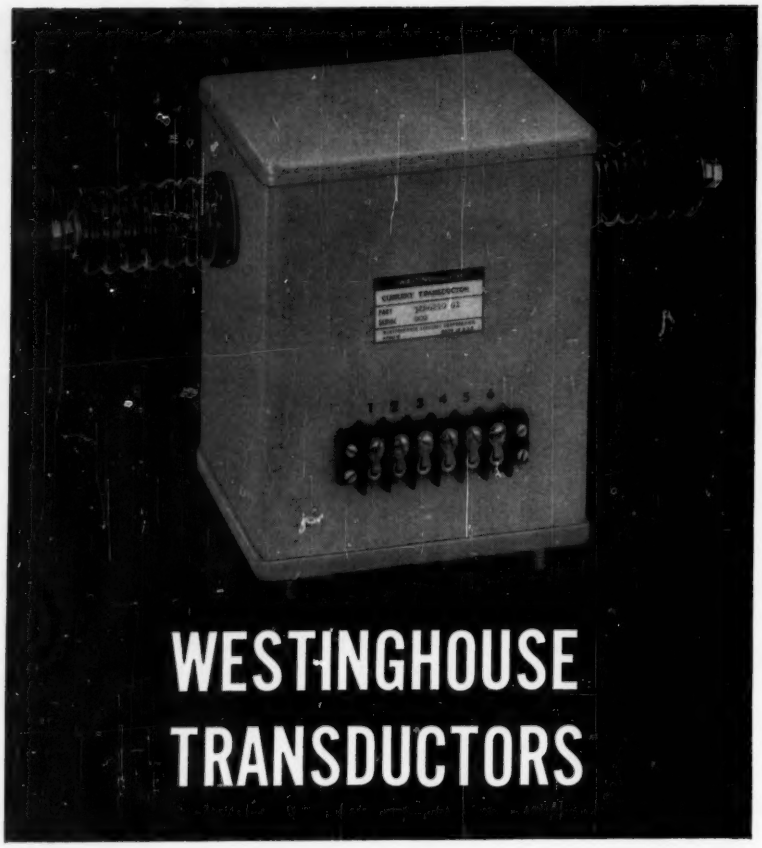

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One of the most respected members of our business staff was W. Donald Boyd, New England district manager, who died on May 17. Don was far more than just an advertising space salesman. He was literally a trusted marketing consultant who helped many of your suppliers solve their basic marketing problems and thus serve you more effectively. Many of these firms can trace part of their corporate growth to specific instances of Don's guidance.

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Don't Overlook MgO

Sir:

Your recent article on "What Materials Beat High Nuclear Heat?" (Apr. 20, pp. 202-206) did not include magnesium oxide in the tabulation on p. 206.

High-purity (96+%) MgO is potentially one of the cheapest ceramic materials available, and no tabulation can be considered complete without it. Melting point of pure MgO is normally listed as 5,070 F.

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E. D. ERMENC
Food Machinery & Chemical
Princeton, N. J.

Pardon the Redundancy

Sir:

In my article, "Estimate Specific Liquid Volumes" (May 4, pp. 137-138), you used in the subtitle the term "specific liquid molal volumes."

This is rather new to me. One may use specific volume *or* molal volume, but specific and molal are seldom used together. I am afraid that some misunderstanding may rise from use of this new term.

Also, the equation in the first column on p. 138 contains a typographical error. The second equals sign should be deleted so that the second and third bracketed terms are multiplied rather than equated.

BENJAMIN C.-Y. LU
University of Ottawa
Ottawa, Canada

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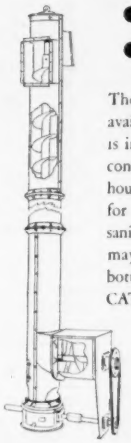

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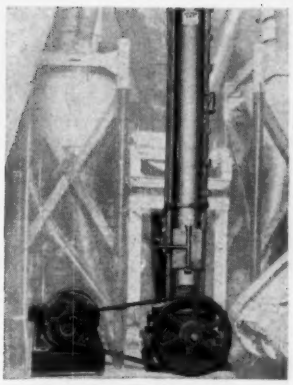

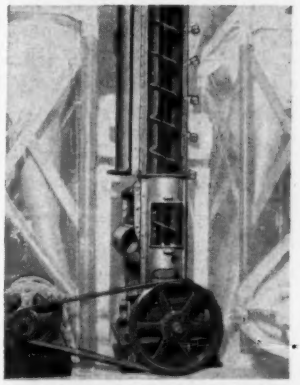

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READER SERVICE . . .

TECHNICAL LITERATURE E. M. FLYNN

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Chemicals

Aluminas.....Services or specifications on any alumina products are available. A copy of a new technical brochure on Aluminas is offered.
149 *Kaiser Aluminum & Chemicals

Ammonium Nitrate.....Users of Ammonium Nitrate in solution form who are interested in information concerning savings on Ammonium Nitrite can obtain it on request.
B153 *Allied Chem., Nitrogen Div.

Caustic Soda.....An easy-to-use fact filled guide book contains data on the safest way to store and handle liquid caustic soda. It is available on request.
21b *Hooker Chemical Corp.

Chlorine.....The Chlorine Manual is now available on request. It contains 76 pages of useful facts on chlorine, its handling and usage. Send for your copy.
21b *Hooker Chemical Corp.

Cyanuric Acid.....developed as an intermediate for chlorinated dry bleaches & sanitizers, is now available to the chem. industry for research & development. Facts.
14-15d *American Cyanamid Co.

Defoamer.....4 p. brochure describes EMKA Defoam recommended for low cost foam and froth control. It is water dispersible, effective in acid and alkaline mixtures.
154A Emkay Chemical Co.

Flocculating Agent.....A new brochure contains complete information on the use and testing of various Cyanamid synthetic flocculating agents including Superfloc 16.
14-15b *American Cyanamid Co.

Germicidal Cleaner.....4 p. brochure WC 1724 describes the types of disease, odor breeding germ life, which Whistleclean D-130 will attack.
154B Whistleclean Corp.

Light Absorber.....Cyasorb UV 24 is a light-stabilizing chemical which substantially improves the color retention & durability of vinyls, polyesters & other resins. Facts.
14-15c *American Cyanamid Co.

Non-woven Fabric.....8 p. brochure describes a new synthetic fiber felt for use in filtration, insulation, chemical and moisture resistance, sound damping, wicking.
154C Troy Blanket Mills

Pelletized Borohydrides....resist crushing or dusting. They are 10/32" & 24/32" in diameter. Bulk density averages five lbs. to the gallon. Complete details.
59 *Metal Hydrides Inc.

Pelleted Sodium & Potassium Borohydride.....are now available in development quantities. All the facts are contained in a Technical Bulletin which is available.
154D Metal Hydrides, Inc.

Polyethylene.....32 p. brochure describes polyethylene's characteristics, applications and markets. Contains 27 charts illustrating properties, production.
154E Spencer Chemical Co.

Polymer Products.....8 p. directory of company's various polymer produces and their specific properties as well as used. Directory includes emulsion & solutions, bead resins.
154F Borden Chemical Co.

Polystyrene.....4 p. brochure details use of expandable polystyrene in a variety of packaging needs. Photographs illustrate use as a shock-absorbent and water-proof pack.
154G Koppers Co.

Polyvinyl Acetate.....5 p. bulletin describes redispersible polyvinyl acetate powder Vinac RP-250 used in joint cements for dry wall construction, spackling.
154H Colton Chemical Co.

Silicone Rubber.....4 p. selector chart CDS-145 contains data on applications, typical properties, primary classes and standard industry & military specs.
154V General Electric Co.

Sodium Nitrite.....Booklet "Sodium Nitrite for Rust and Corrosion pre-Vention" contains details about the many anti-corrosion uses of Sodium Nitrite. Also test sample.
67 *Allied Chem., Solvay Process Div.

Urethane Foam.....Data sheet 31859 describes the advantages of using the company's Genetron 11 as a blowing agent for rigid urethane foams.
154J Allied Chemical

Water-soluble Resins.....Two new Cyanamer water-soluble acrylamide polymers, P250 and P26, dissolve fast, give clear solution. Information available.
14-15a *American Cyanamid Co.

Yttrium.....Data sheet covers many characteristics of the rare earth metal regarding thermal properties, crystal structure, electrical properties, corrosion data.
154K Nuclear Corp of America

* From advertisement, this issue

Construction Materials

Coating.....Kanigen nickel-alloy coatings provide corrosion resistance & product contamination protection to process equipment of any size. Bulletin #258.
166 *Generall Amer. Transp. Corp.

Flooring, Industrial.....Bulletin describes a new type of ready-to-lay flooring that is claimed to outwear concrete. Suitable for use over concrete, wood, metal.
154L Monroe Co.

Packing.....Centripac packing is designed specifically for single-stage centrifugal pumps in the process industries. Speed to 3600 rpm; Temp. to 500F. Information.
157 *Johns-Manville

Packing.....Bulletin S-29R contains information about Intalox Saddle Packing. Increase capacities & lower pressure drops when used for packed towers.
36 *U. S. Stoneware

Packings, Hydraulic.....16 pages of important engineering data are contained in a new brochure on homogeneous & fabric reinforced hydraulic packings. Bul. P-333.
154M Crane Packing Co.

Protective Coating.....4 p. brochure describes a new epoxy coating for floors, walls, machinery which drys and hardens to a "baked-like" finish thanks to a special catalyst.
154N Galand Co.

Protective Topping.....4 p. leaflet Bulletin 510, describes Nu-Klad 510, a new epoxy compound for use as a protective topping for concrete, wooden & steel surfaces.
154O Nukem Products Corp.

Reactor Metals.....Forms and sizes of General Plate Reactor Metals—boron-stainless steel alloys, hafnium, tantalum, zirconium, etc.—are described in new bulletin.
154P Metals & Controls

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Stainless.....No. 20 & 20Cb are as easily fabricated as ordinary stainless steels. Forms, sizes & shapes for most corrosion problems. Tech. bulletin 108A.
147 *Carpenter Steel Co.

Synthetic Rubber.....Viton has good mechanical properties plus resistance to oxygen, ozon & weathering. Complete technical information available.
176 *E. I. du Pont de Nemours

Electrical & Mechanical

Conduit and Fittings.....New handbook of conduit and fittings features descriptions of installations, specifications, applicable electrical data. Contains 60 pages.
155A National Supply Co.

DC Motors.....Pamphlet describing DC motors provides a convenient reference that may be inserted in manufacturer's Product Data Catalog. Aircraft and missile motors.
155B Lear

Electrical Wiring.....A new 15-page booklet covers the complete line of equipment & new ideas in wiring. Included are specification & application charts. Bul. 159-1.
155C Appleton Electric Co.

Fixtures.....“EFU” explosion-proof fluorescent fixtures are available in 2, 3, or 4 lamp models. Wattages, types of fixtures or complete specifications offered.
38 *Appleton Electric Co.

Motors.....that will not corrode. Complete information on 1 to 125 hp corrosion-proof motors is contained in Bulletin B-2406 which is now available.
178 *Reliance Electric & Engr. Co

Motors.....All windings are insulated with asbestos. Color-illustrated brochures contain specific data on asbestos protection. General & Type H Uniclosed bulletins.
31 *U. S. Electrical Motors, Inc.

Motors.....Type DP is available with ball bearings or with high load carrying capacity sleeve bearings for extra quiet operation. Bulletin Mu-223.
73 *Wagner Electric Corp.

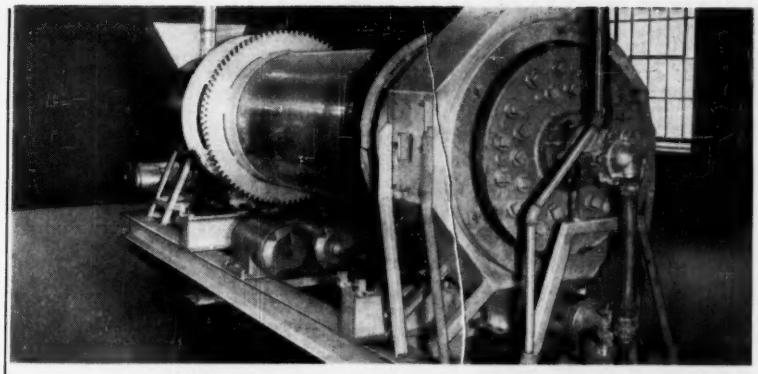
Seals, Mechanical.....A new file folder of mechanical seal designs shows some of the many types & applications possible for pumps, mixers, autoclaves, etc.
145 *Borg-Warner

Turbines.....Illustrated Catalog 200 covers design of different types of turbines. Features drawing of cross sectional view of horizontal turbine. 13-pages of information.
155D Coppus Engineering Corp.

Handling & Packaging

Bucket Elevator.....Complete range of systems & components for elevating bulk materials from fines up to 8″ lumps. Types, weights, dimensions, etc. in 96-page catalog.
35 *The Jeffrey Mfg. Co.

* From advertisement, this issue



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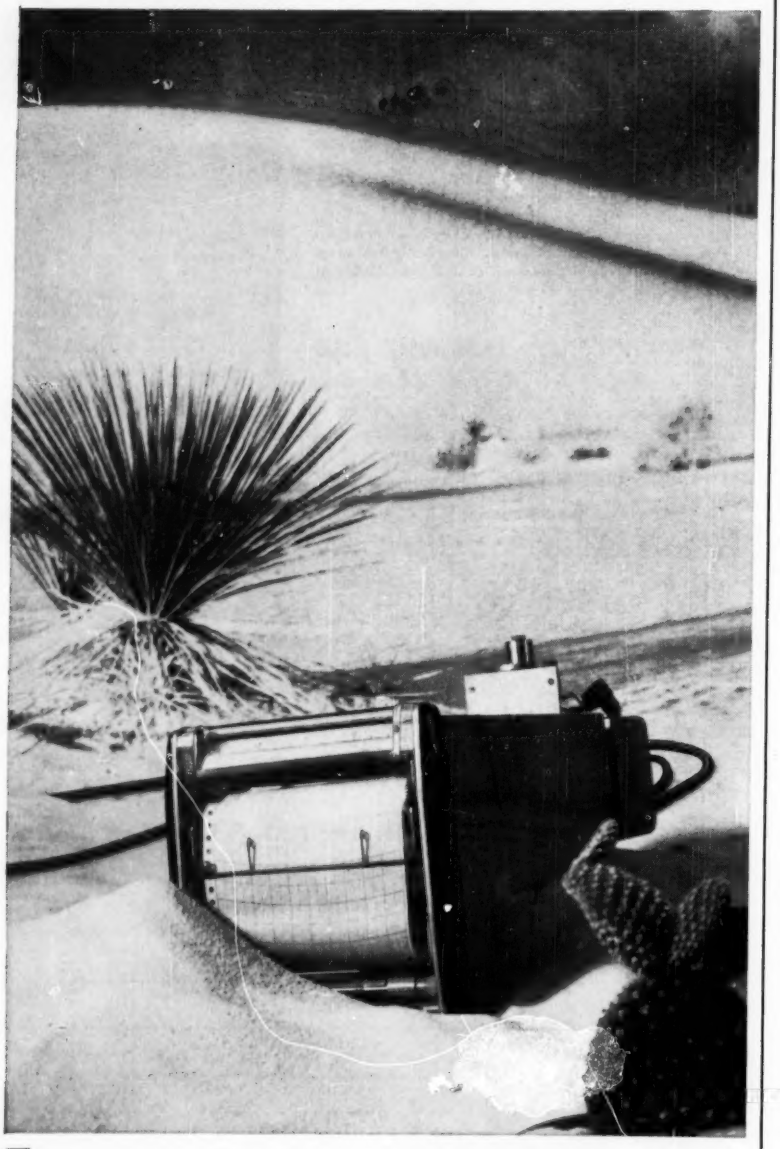

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LITERATURE . . .

Dry Chemical Feeder.....Series A-728 forms a base for a complete feeder installation. Standard components are available. Information to help you build your own feeder.
146 *Wallace & Tiernan Inc.

Flow Control Valves.....Provide easy, accurate flow control of bulk materials from bins and chutes. Iris-type diaphragm resists jamming. Bulletin available.
156A Syntron Co.

Fork Lift Trucks.....Three new pieces of literature about the manufacturer's line of fork lift trucks are available. Capacity range covered is 2,000 to 10,000 lb.
156B Allis-Chalmers

Fork Trucks.....Condensed catalog of fork trucks contains detailed engineering data, specifications and operating information on more than 25 basic fork truck models.
156C Elwell-Parker

Lift Truck.....Important controls are at the operator's finger tips. Offers plenty of leg-stretching room on the clean lever-free platform of the lift truck.
164 *Allis-Chalmers

Materials Handling.....The self-loading Dumpmaster handles 6 sizes of containers. One man operation . . . can't injure operator. Brochure gives all the facts.
139 *Dempster Brothers

Metal-Mesh Belts.....combine movement with processing to give you greater production & consistently high quality without costly manual handling. 130-Pg. Manual.
131 *The Cambridge Wire Cloth Co.

Packaging Guide.....Revised edition of "How to Pack It" gives information on selection of corrugated packaging for a new or existing product. Fully illustrated.
156D Hinde & Dauch

Plastic Bottles.....The Plastic Bottle Comes of Age" explores the market for Hi-Fax high-density polyethylene bottles. Competitive in cost with glass and metal.
156E Hercules Powder Co.

Remote Weight Recording.....Late accomplishments in the field of transmitting and processing of weight data are described in a new, illustrated, eight-page brochure.
156F Toledo Scale Corp.

Screw Elevators.....The Rotor Lift is quick opening, easy to clean, & fast closing. Eight basic types, four diameters. Engineering Catalog offered.
T153 *Southwestern Supply & Machine

Tanks.....Glasteel Chemstor tanks are ideal for products that tend to cling. They protect against corrosion & contamination & feature high strength. Details in Bul. 918.
178 *Pfaudler Co.

Tractor-shovel.....The model H-25 "Pay-loader" tractor-shovel has a carry capacity of 2.500 lbs. Offers full-reversing powershift transmission. Data.
32 *The Frank G. Hough Co.

Trailer, Gas Supply.....the modern method of transporting compressed gases. Feature capacities to meet your requirements & safety cylinders & devices for protection.
B158 *Independent Engineering Co.

* From advertisement, this issue.

News and Notes on...

Good Packing Practice

JOHNS-MANVILLE JM PRODUCTS

Maintenance and Design Hints from Johns-Manville Packings and Textiles Dept.

Subject of the month: Trouble-shooting Packing Problems

Question:

How can you pinpoint the cause of a premature failure?

If you carefully examine used packing, a correct interpretation of the damage will often suggest exactly what caused a premature failure.

Generally speaking, the reasons fall into three areas: (a) the wrong size or style packing was selected for the particular service conditions, (b) the packing was not properly installed, or (c) the equipment requires maintenance. And any of these three conditions can not only result in premature packing failure . . . but can lead to other headaches resulting from poor performance of equipment.

Let us review some of the most common types of packing failures and their causes . . . easy to recognize through a careful inspection of the damaged packing.

1. ***Damage:*** Excessive reductions in the cross-section of the packing.

Possible cause: Bearing worn, or other shaft misalignment result in eccentric movement such as shaft "whip."

2. ***Damage:*** Wearing face of the rings dried and charred, but the rest of the packing is still in good condition.

Possible Cause: Either lack of proper lubrication, or the packing was not designed to withstand speed of movement involved, or the temperature range of service encountered.

J-M #7 Centripac® Packing shown here is designed specifically for single-stage centrifugal pumps in the process industries. Speeds to 3600 rpm; temperature to 500F.

3. ***Damage:*** One or more rings missing from set.

Possible Cause: Bottom of the stuffing box is badly worn, and allows the packing to extrude into the system, causing possible contamination.

4. ***Damage:*** Wear on outside diameter of the packing.

Possible Cause: Rings rotating with the shaft, or coming loose in the box. Choosing the correct size of packing will eliminate this problem.

To solve any sealing problem, call on your local J-M Packing Distributor or Johns-Manville representative. They are equipped to help you select the right packing for the job—one that insures long, trouble-free service. For information, write to Johns-Manville, Box 14, New York 16, N.Y. In Canada: Port Credit, Ontario.

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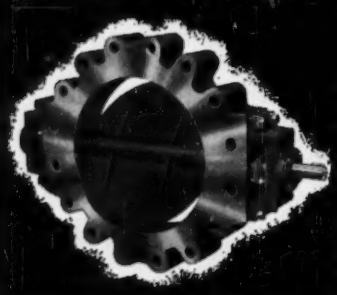

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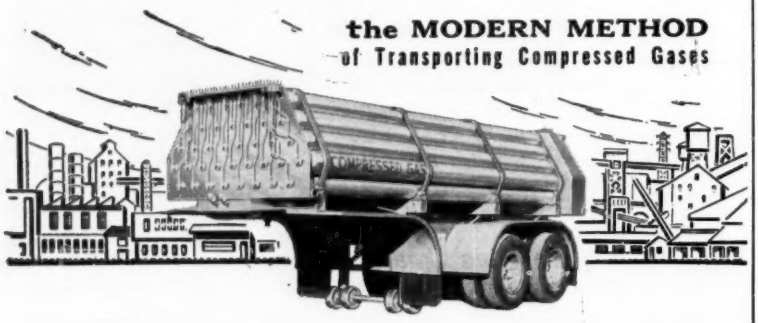

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Heating & Cooling

Exchangers, Scraped Surface.....for special heat transfer & crystallization problems are fully covered in literature which is available on request.
111 *Henry Vogt Machine Co.

Fluid Bed Dryer.....New bulletin tells of the operation and features of the H & P Fluid Bed Dryer. Unit is adaptable to many process applications for thermal drying.
158A Heyl & Patterson, Inc.

Heat Exchangers.....New bulletin describes features of ALCO finned-tube heat exchangers and other longitudinal finned-tube products. Design and specifications.
158B ALCO Products, Inc.

Heat Exchangers.....Engineers who have occasion to specify heat exchangers may welcome a specifications manual on double-pipe or hairpin heat exchangers. Indexed.
158C Brown Fintube Co.

Heat Transfer.....Multi-Zone Plate-coil provides for higher pressure containment & a margin of heat transfer capacity. Bul. P61 for complete data & performance.
129 *Tranter Manufacturing Inc.

Kilns, Rotary.....have all welded steel shells, feed & discharge end seals, heat recuperating chain systems for wet process kilns, improved kiln feeders, etc. Bul. 1115.
4 *Traylor Engr. & Mfg. Co.

Steam Traps.....A 48-page book tells how to correctly size, install & maintain steam traps for any pressure, temperature or any load. Also catalog data on all types.
119 *Armstrong Machine Works

Steam Traps.....Four-page bulletin discusses typical applications, capacities and construction of the manufacturer's line of steam traps. Diagrams included.
158D Ross Midwest Fulton

Instruments & Controls

Analyzers.....Bulletin describes the features and applications of infrared, photometric, thermal conductivity, combustibles and trace oxygen analyzers.
158E Analytic Systems Co.

Auto Analyzer.....conducts continuous automatic wet chemistry determinations with a precision of ±1% . . . without attendance. Brochure & application data available.
45 *Technicon Controls, Inc.

Gage, Multi-Pointer.....Features, compact size, choice of colors, fluorescent illumination, colored scales, unlimited indications, etc. Additional information available.
30 *Bailey Meter Company

Gas Analyzers.....Features of Thermal conductivity Gas Analyzers are covered in an 8-page booklet. Folder ND46-91(6) gives data on this equipment.
117 *Leeds & Northrup Co.

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63c—"Tri-Lug" union

63d—Socket weld union

65a—Horizontal turbine

65b—Vertical turbine

65c—Fanmix gas burner

65d—Fanmix gas-oil burner

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* Don't forget to ask for your copy of this issue's free reprint feature (p. 89).

an unbeatable combination . . .

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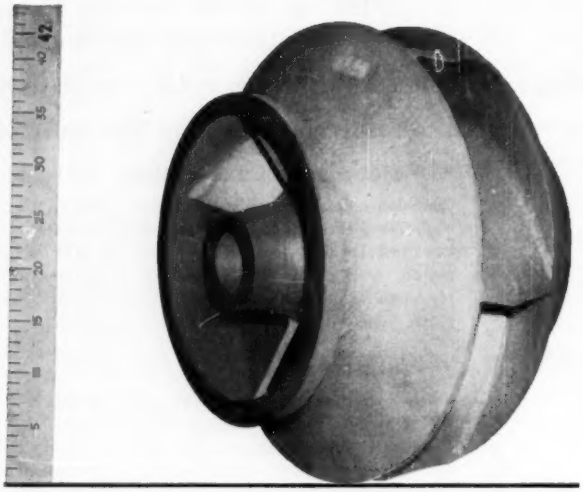

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Liquid Level Control.....Provision for operating and safety controls for a wide variety of jobs involving liquid level and flow is the topic of Bulletin ERS-A.
162A McDonnell & Miller, Inc.

Liquid Meters.....The Metering Data Bulletin 56[illegible] offers complete information a[illegible]t liquid meters. All the facts ava[illegible]able on request. Send for your copy.
165a *Neptune Meter Co.

Moisture Monitors.....Applications, features, operating characteristics, specifications and other details of portable moisture monitors are discussed in new brochure.
162B Consolidated Electrodynamics

Secondary Liquid Level Indicator..... Bulletin WG-1824, Supplement B describes new miniature transistorized Secondary Liquid Level Indicator. Construction details.
162C Yarnall-Waring Co.

Spectrograph.....Text of "Norelco Autrometer, Automatic Indexing X-Ray Spectrograph deals with applications, operating principles and procedures, specifications, etc.
162D Philips Electronics

Stainless Steel Meter.....for corrosive liquid batching, transfer, cost accounting, processing, etc. Only two moving parts contact the liquid. Facts available.
165b *Neptune Meter Co.

Strip-Chart Recorder.....Brochure covers strip-chart recorders that combine exceptional versatility with light weight and compactness. Accessories and chart-speed options.
162E Varian Associates

Transducers.....for accurate instrumentation, metering & control of high-voltage direct-current systems. Complete information available.
152 *Westinghouse Electric Corp.

Pipe, Fittings, Valves

Acid Hose.....has a cover of tough abrasion & acid resistant rubber. Hose ends are rubber sealed. It remains flexible even when cold, & is resistant to weathering.
125 *Acme Hamilton Mfg. Corp.

Pipe Aluminum.....Expanded availabilities of extruded aluminum pipe in Schedules 5, 10, 40 and 80 are listed in a new six-page brochure.
162F Kaiser Aluminum

Basic Check Unit.....combined with a standard pipe fitting for a complete check valve. Available in seven standard line sizes from ⅜" to 2". Bul. CE 69.
141 *Durabla Manufacturing Co.

Pipe.....Saran Lined Pipe, fittings, valves & pumps are available for systems operating from vacuum to 300 psi, from below zero to 200 F. Information available.
51 *The Dow Chemical Co.

Pipe & Fittings.....Data on Fluoroflex-T type S pipe & fittings is available. Corrosion-proof for service to 500 F in chemical & corrosive solutions. Bul. TS-1A.
115 *Resistoflex Corp.

* From advertisement, this issue.

Pipe, Flexible Poly.....ideal for water lines, drains, underground pipe or conduit. Sizes ½ to 2", long coils. Additional information in Bul. CE-57.
143c *American Hard Rubber Co.

Pipe, PVC.....performance data is available on corrosion resistance, allowable stress, temp., pressure, impact, vibration, etc. New 32-page illustrated catalog offered.
61 *A. M. Byers Co.

Pipe, PVC.....Easy to install, it can be threaded, cut, welded, drilled. It has excellent insulation properties, is unaffected by most alkalies & acids. Pipe & Sheet Booklets.
1 *B. F. Goodrich Co.

Pipe, PVC.....All-purpose rigid PVC In schedules 40, 80, & 120, ½ to 4". Threaded or socket-weld fittings. More information in Bulletin CE-56.
143a *American Hard Rubber Co.

Pipe, Stainless Steel.....The right grade and size is available . . . seamless or welded. Complete information contained in Bulletin TB-410.
49 *The Babcock & Wilcox Co.

Unions.....These unions have four different seats for every general piping requirement . . . each completely interchangeable. Complete information including prices.
63a *Rockwood Sprinkler Co.

Valve Controls.....The new Limitorque Type P-2 for motorized automatic operation of small globe and gate valves is outlined in special Bul. 21-58.
34 *Philadelphia Gear Corp.

Valves.....Floating-Stem valves offer advantages such as; no backlash, pre-loading construction, etc. Offer choice of lower stem materials. Details in Bul. 5152-A.
148 *Autoclave Engineers, Inc

Valves.....Rubber-lined gate valves give you advantages of the revolving double disc parallel seat & "no pocket" discs . . . which provide positive sealing. Information.
16 *Darling Valve & Mfg. Co.

Valves.....Type K "Y" valves are available in Durimet 20, Durco 18-8-S-Mo, Monel, Nickel, Chlorimet 2 & Chlorimet 3. Complete details in Bul. V/7a.
133 *The Duriron Co., Inc.

Valves.....Wide selection of valves & features plus such accessories as pneumatic & electric valve positioners for hysteresis-free control & a complete line of controllers.
123 *Republic Flow Meters Co.

Valves, Acid Proof.....Many types available in Tufclad chemical porcelain in ½" to 6" sizes. Description & specifications on the entire line is available.
53 *Lapp Insulator Co., Inc.

Valves, Butterfly.....for gas, vapor, liquid or semi-solid control problems. Simplicity of design makes them easy to service & maintain. Literature.
T158 *Fisher Governor Co.

Valves, Ball.....Illustrated booklet contains a general summary of design features & advantages, industrial applications, maintenance, material, and sizes.
163A Jamesbury Corp.

* From advertisement, this issue.

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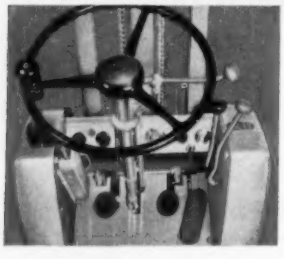

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LITERATURE . . .

Valves Bypass.....Bulletin 8F describes a line of three-way feedwater-heater bypass valves for regulating boiler feedwater flow. Valves serve at 3,500 psi. and 500 F.
164A Schutte & Koerting Co.

Valve Check.....Positive-shutoff check valve offers increased life and virtually eliminates valve failure. Checks flow only when pressure is changed. Corrosives to 2,000 psi.
164B Robert H. Wager Co.

Valves, Fittings, Piping.....Catalog 356 contains complete details including charts, diagrams & other illustrations on jacketed piping, fittings, plug valves, joints, etc.
164C Parks-Cramer Co.

Valves, gate.....Complete specification on "craneloy 20" stainless steel valves is contained in Circular AD-2080 which is available on your request.
85 *Crane Co.

Valves, Gate.....In a wide range of corrosive & erosive services these valves withstand corrosion. Information folder No. 205 gives details on Ni-Resist valves.
87 *Jenkins Bros.

Valves PVC.....Brochure covers all-molded, corrosive-resistant PVC valves. Information on sizes, weights and dimensions. Table of corrosive fluids and their effect.
164D Lunkenheimer Co.

Valves, Stainless Steel.....Full details on three new light, low-cost stainless steel valves are featured in a new section to the manufacturer's Catalog 425.
164E W. G. Rovang & Associates

Process Equipment

Continuous Centrifuge.....Bulletin describes Type OG heavy-duty centrifugal separators, which are designed for purifying and dewatering lubricant and fuel oils.
164F Centrico, Inc.

Crushing & Grinding.....Design provides easy access for cleanouts. Returns complete sample. Bulletin No. 067 gives full description of all laboratory machines.
150 *Sturtevant Mill Co.

Dissolvers.....for ultimate dispersion, disolving, emulsifying & deagglomerating in processing solid-liquid, liquid-liquid & gas-liquid materials. Catalog.
71 *Morehouse-Cowles, Inc.

Dryer.....Complete information on vacuum chamber dryers is available on request. Special designs to solve any of your chemical processing problems.
B174 *J. P. Devine Mfg. Co.

Filters.....Process Filters makes available pilot plant test filters. Data folders "Batch Recovery", "High Solids Removal", "Polish Filter" are offered.
55 *Bowser, Inc., Process Filters

Filters.....Bag-Type for filtering amine or glycol solutions. Will remove foreign solids as small as .0017". Filters available in a wide range of sizes & types.
174 *Wm. W. Nugent & Co., Inc.

* From advertisement, this issue.

Filter Systems.....Bulletin # 103 describes the advantages of Dulaire jet-cleaned filter systems. They collect dust from industrial processes. No down time for cleaning.
113 *Western Precipitation Corp.

Centrifuge, Hermetic.....Corrosion-resistant and easy to clean, these centrifuges meet all the requirements of industrial service. Details available on request.
12-13a *The De Laval Separator Co.

Mill, Colloid.....The RE* Two Stage Colloid Mill is available in models with a capacity range from 0-2600 GPH. Illustrations, capacity data, etc. in Bul. C-57.
165A Manton-Gaulin Mfg. Co., Inc.

Mills, Roller.....for pulverizing an extremely wide range of products & to handle various types of raw materials from mines, pits, quarries, etc. Catalog No. 79.
86 *Combst. Engr. Inc., Raymond Div.

Mills, Roller.....Designed for quality fine grinding . . . 20 mesh to 400 mesh . . . micron sizes on some materials. Exclusive gearless & spur gear drives. Facts in catalog.
57 *Williams Patent Crusher

Mixers.....A full line . . . side drive, tank top, portable or tripod, and continuous pipeline mixers. Details on mixers for all fluid mixing needs. Bul. 582.
8-9 *Nettco Corporation

Plate Heat Exchanger.....The stainless steel plate construction assures a long life and quick access for easy cleaning when required. Information.
12-13b *The De Laval Separator Co.

Processing Equipment.....Catalog 386 "Buflovak Processing Equipment" outlines the sound research, expert engineering, on-schedule delivery & customer service.
24-25 *Blaw-Knox Co.

Separator, Syncro-Matic.....is constructed of carbon steel or stainless steel. Accommodates a full range of screen sizes & is available in 1, 2, or 3 decks. Details.
12-13c *The De Laval Separator Co.

Tube Mill Equipment.....Detailed information on extra-long tubes, U-bend, Dual-gage, or Duplex tubes to meet special problems is available.
127 *The American Brass Co.

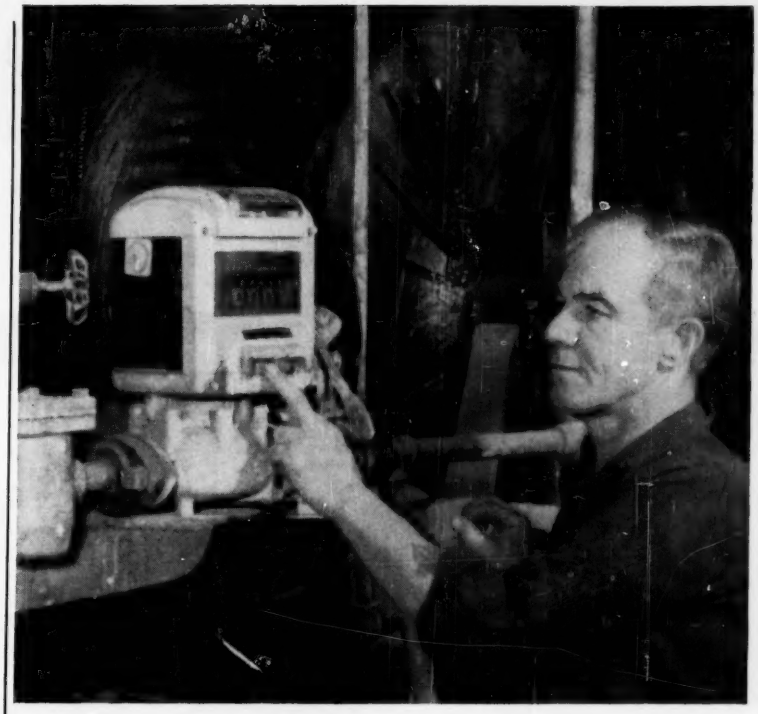
Pumps, Blowers, Compressors

Air equipment.....Information on Aftercoolers and Separators contained in Bul. #712. Bul. #117 on Poro-Stone Air Filters is also available.
144 *R. P. Adams Co., Inc.

Compressors.....Axial-flow & Centrifugal compressors can be designed to your specifications. Standard models are also available. Bulletin "Joy Turbodynamics."
7 *Joy Mfg. Co.

Compressors.....Bulletin 350 illustrates the 3-AT Compressor—a horizontal, water-cooled, single-stage, heavy-duty compressor for compressed air applications.
165B Pennsylvania Pump

* From advertisement, this issue.



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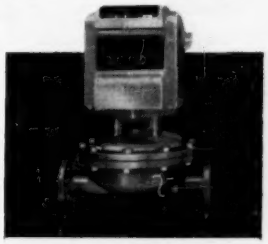

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Exhausters, Cast Iron.....are available with direct motor drive, separate belt drive or package unit with adjustable V-belt drive & motor. Full information.
151b . *Buffalo Forge Co.

Fans.....Resin-bonded fiber glass fume fans are corrosion-resistant, impact-resistant & won't support combustion. Details including chem. resistance tables, Bul. FI-511.
151a *Buffalo Forge Co.

Pump Gear.....Improved design . . . now 12 gph. All wetted parts are acid-resistant and wear-resistant. For complete details on these gear pumps—Bulletin CE-55.
143b *American Hard Rubber Co.

Pumps, Glassed Centrifugal.....Choose from 4 different sizes & get capacities up to 700 GPM, heads up to 140 ft. Bul. 725.2 plus "It's What's Inside That Counts", offered.
121 *Goulds Pumps, Inc.

Solids Pumps.....Bulletin 189 covers the capacities of the new type CK solids pump, which handles fluids containing random-size solids and highly abrasive materials.
167A Morris Machine Works

Pumps, Stock.....Type 2-SOD-11 & 3-SOD-11 for pulp & paper mills are outlined in Bulletin 235. Drawings, dimensions & conversion table are included.
167B Warren Pumps, Inc.

Services, Processes, Misc.

Fiber Research.....7 p. booklet illustrates and describes the objectives and equipment of a new fiber products research center sponsored by six interested companies.
167C Fiber Products Research Center

Film Documentation.....Booklet available on request tells of the capabilities of organization that provides technical-film documentation services to industry.
167D Cook Electric Co.

Industrial Gases.....Capacity to design, produce, install & operate complete systems for separation, purification & liquefaction of gases. Information.
17-20 *Air Products Inc.

Laboratory Glassware.....36 p. Supplement No. 3 to Catalog LG-1 contains specifications and sketches of a full line of standard and custom made laboratory ware.
167E Corning Glass Works

Laboratory Homogenizer.....is a single plunger, positive displacement machine for efficient & economical processing of industrial emulsions & dispersions. Outlined in bulletin.
167F Manton-Gaulin Mfg. Co., Inc.

Load Cells & Load Beam.....provide a new & practical approach to weighing & force-measuring problems. Bul. 4355 gives detailed information on all standard types.
167G Baldwin-Lima-Hamilton Corp.

Manufacturer's Facilities.....New brochure contains photographs and data about Epsco—its facilities and products. Title is "First in Data Control."
167H Epsco, Inc.

Measuring Device.....Handy slide rule for calculating polyethylene film & bag measurements covers width, length, total area, weight and gauge in a simple clear manner.
167I U. S. Industrial Chemicals

Portable Fire Extinguishers.....Two new stainless steel portable feature simple, one-two operation. Slim design & light weight for easy storage & handling. Information.
140 *Walter Kidde & Co., Inc.

Radiation in Industry.....Booklet covers use of X- and gamma rays for nondestructive inspection and product testing. One section deals with effect on product.
167J Picker X-Ray Corp.

Recording Systems.....Methods of reducing signal dropouts in magnetic tape are discussed in "Sound Talk" bulletin 37, 4 p. Improvements are due to coating.
167K Minnesota Mining & Mfg. Co.

Reference Charts.....Brochure contains engineering constants, short-cut tables, formulas and other technical plant data. Mixer information. Free on request.
167L Falcon Mfg. Div.

Service Foundry.....makes many large stainless steel castings for the chemical industry. A complete brochure, Foundry Work-Steels, Alloys & Non-Ferrous offered.
162 *Avondale Marine Ways, Inc.

Sterile Water.....Steril-Aqua system produces sterile pyrogen-free water from boiler steam. Bulletin contains diagrams, specifications and discussion of system features.
167M Wilmot Castle Co.

Structures.....Coordinated services to meet exacting specifications and schedules. Bulletin: Development of the Oil Storage Tank is now available.
Cover *Chicago Bridge & Iron Co.

System.....Boltaron 6200 handles chemical & industrial fumes safely & economically. Information on performance-proven Boltaron 6200 systems is available.
69 *The General Tire & Rubber Co.

Testing & Research.....4 p. bulletin 5901 describes a complete line of chemical laboratory testing and research facilities. Products tested include drys, fuels, dyes.
167N U. S. Testing Co.

Torque Wrench.....Illustrations, capacities & dimensions of the Sensory Signalling torque wrench and the Standard Model torque wrench are contained in a new bulletin.
167O P. A. Sturtevant Co.

Typewriter Ribbon.....4 p. bulletin describes long-lived nylon ribbon made by crimped weave process. Ribbon absorbs 8 times more ink, controls ink flow.
167P Remington Rand

Viscosity Control equipment.....New Bulletin No. V-1224 describes the viscosity Control equipment for automatically adding solvent to correct for evaporation losses.
167Q Norcross Corporation

Water Bath.....is ideal for laboratories doing quality control, research, & educational work. Features removable clamp rods, bottle feed, inside shelf, etc. Bul. 151.
167R Barnstead Still & Sterilizer Co.

* From advertisement, this issue

* From advertisement, this issue

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2—Sharples PN14 Super-D-Canters, 316 S.S.
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4—Sperry 36" rubber covered P & F Filters, 30 chambers
2—Sperry 42" Aluminum Recessed Filters, 30 chambers.
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2—Rennenberg 6' x 60" Rotary Kilns, 5/8" shell riveted.
1—Proctor & Schwartz 8' wide x 60' long Conveyor Dryer, Stainless Steel Belt.

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4—3400 gal. 8' x 8' with Nettco Turbo Agitators, 15 HP.
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1—36" Tolhurst, bronze center-slung.
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1—30" Fletcher, underdriven, T304 SS.
1—26" Fletcher, underdriven, T316 SS.
1—26" Tolhurst, susp., steel perf.
1—12" Fletcher, underdriven, T304 SS.

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3—Bird 24" x 24", slotted screen monel.
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1—9' x 100' Vulcan, ⅝" shell Kiln.
1—8' x 170' ¾" shell, 3-tire Kiln.
1—8' x 115' ⅝" shell, 2-tire Kiln.
2—8' x 50' Vulcan, ⅝" shell Kilns.
2—7'6" x 100', ½" shell Kilns.
2—6' x 60' ⅝" shell Kilns.
1—4' x 24', 2-tire Kiln.
4—Hardinge 8'6" x 70' Dbl. shell dryers, #XA-18, welded, ½" shell.
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2— 80 sq. ft. Devine, UNUSED.
1— 36 sq. ft. Stokes, Steel.
1— 24 sq. ft. Stokes, Steel.
1— 12 sq. ft. Stokes, Steel.

$3,000,000.00 LIQUIDATION

Type 316 Stainless Steel Equipment

CHEMICAL PLANT—ORANGE, TEXAS

STAINLESS STEEL COLUMNS

1—108" Dia. Vulcan scrubber, 10 trays on 12" centers, 252—bubble caps per tray.
1—96" dia. x 13' high scrubber, 10 stainless steel trays on 12" centers, 276—caps.
2—96" dia. x 35' high bubble cap columns, 30 trays, 12" spacing, 272—caps per tray.
2—60" dia x 13' high, Vulcan scrubbers, ¼" shell, 10 trays, 100—caps per tray.
2—48" dia. columns, 30 & 25 trays, bubble caps, T316 SS.
3—30" dia. packed columns, 25' high, T316 SS.
4—24" dia. bubble cap columns, 12 trays, T316 SS, 18" spacing.—Vacuum.
2—20" dia. stainless steel columns, 25' & 30' high.

COPPER COLUMNS

1—72" dia. Vulcan bubble cap copper column, 46'10" high, 40—trays.—Vacuum.
2—48" dia. bubble cap copper columns, 25 & 40 trays, 31' & 45' high.—Vacuum.
2—42" dia. Vulcan stills, 66" high. (Evaporator bodys).
1—24" dia. column, 25 2½" long, 20 trays.

FILTERS—CRYSTALLIZERS

2—Bird-Young 4' dia. x 3' face rotary Vacuum filters. T316 SS, 40 sq. ft.
3—Sharples C-20 Super-D-Hydrators T316 SS.
1—Alco 60 sq. ft. vertical pressure leaf filter, T316 SS.
3—18,000 gal. Aluminum Cone bottom tanks, 12' dia. x 31' O.A.H.
4—1200 gallon Crystallizers, T316 SS, 5' dia. x 7' high, dished top, conical bottom.
7—560 gallon Crystallizers, T316 SS, 3'6" dia. x 7" high, dished top, conical bottom.
3—Worthington 160 Ton steam jet refriqeration units.
1—Pneumatic Conveyor System, approx. 1150' 10" dia. Aluminum Pipe.

TYPE 316 STAINLESS STEEL KETTLES

4—3,500 gal. jacketed kettles, 7' dia. x 12' high, T316 SS. 11/32" shell, dished heads, 11 turns SS coil, two-speed agitator, 40/20 HP-1750/500 RPM.
1—2,500 gal. 6' dia. x. 12' high, T316 SS, horiz. still kettle.
3—1,000 gal. 5'6" dia. x 6' high, T316 SS, int. coils, turbine agit.

TYPE 316 STAINLESS STEEL TANKS

1—17,650 gal. 9' dia. x. 36' long, T316 SS, ¼" shell, ⅜" heads w/coil.
2—7,500 gal. 10' dia. x 13' high, T316 SS, ½" shell, w/10 HP SE agit.
2—6,500 gal. 11' dia. x 7' high, T316 SS, 7/16" shell, ½" heads.
12—2,300 gal. 7' dia. x 8' high, T316 SS, ¼" shell, coils (some with agitator).
2—2,000 gal., 6'6" O.D. x 8' long, ¼" shell.
5—1,100 gal. 5'6" dia. x 6' high, T316 SS, w/coils, with agitator.
4—1,200 gal. 5' dia. x 7' high, dished top, 42" deep conical bottom (crystallizer tanks).
7—560 gal. 3'6" dia. x 7' high, ¼" dished top, 4' deep conical bottom.
55—Tanks and Pots from 10 gal. to 350 gal. sizes, vertical and horizontal, dished heads.

CONDENSERS—HEAT EXCHANGERS—CALANDRIAS—COOLERS

1—1,450 sq. ft. condenser, stainless steel tubes, tube sheets, heads, and baffles.
1—1,200 sq. ft. condenser, stainless steel tube, steel shell.
14—750 & 800 sq. ft. stainless steel condensers, vertical, T316 SS tubes and heads.
9—Condensers, 356, 400, 410, and 550 sq. ft., T316 SS.
5—Calandrias, 140, 145, 150, 157, 250, 277 sq. ft., T316 SS.
11—Exchangers 64, 70, 75, 80, 100 sq. ft., T316 SS.
12—Exchangers 20, 30, 47, 50, 52, 54 sq ft., T316 SS.
15—Cupro-Nickel & Copper exchangers, up to 1070 sq. ft.

MISCELLANEOUS EQUIPMENT

10,000—T316 SS pipe & tubing, 1", 2", 3", etc.
2,000—Valves, T316 SS, up to 10"
1—Otis elec. freight elevator, 5000# @ 75 FPM
40—Stainless steel pumps 1" to 6", 1 HP to 20 HP.
3—Steel columns: 48", 30", 20" dia.
2—St. St. bucket elevators, 62' and 45' high.
4—Stainless steel screw conveyors and chutes.
1—2,000 gal. aluminum tank, 6' dia. x 10' high, coils.
25—Stainless steel steaam jet evactors and ejectors.
18—Separators, T316 SS, 22" x 8' overall depth, cone type.
1—Croll-Reynolds #21 jet vacuum air pump, capacity 50# per hour.
Also Stainless steel valves, pipes, steel tanks, pumps, stainless agitators, etc.

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GELB

CHEMICAL PROCESS EQUIPMENT VALUES

2—Sturtevant #7 dustless type 304 SS batch blenders, NEW
1—Swenson 10′ dia. SS spray dryer, complete
1—Readco SS 25 gal. jacketed vacuum sigma blade double arm mixer
1—Cleaver Brooks 500 HP package steam generator, 200#

AUTOCLAVES, KETTLES AND REACTORS

4—Steel & Alloy Tank Co. 100 gal. type 347 SS, pressure tanks, 250# pressure
1—Steel & Alloy Tank Co. 300 gal. type 347 SS, pressure tanks, 250# pressure
1—Steel & Alloy Tank Co. 125 gal. type 347 SS jacketed autoclave, 250# internal and jacket pressures
1—Steel & Alloy Tank Co. 200 gal. type 347 SS jacketed autoclave, 250# internal and jacket pressures
1—Blaw-Knox 400 gal. steel jacketed autoclave, 570# internal pressure, 85# jacket
1—Columpia Engineering high pressure storage tank, 2400 gal., 265# working pressure
2—Pfaudler type 316 SS 700 gal. jacketed kettles with condensers, columns and receivers
2—Pfaudler 316 SS 750 gal. jacketed vacuum reactors

DRYERS

4—Link Belt steel roto louver dryers, Model 207-10, 310-16, 310-20, 604-20
1—Buflovak double drum dryer, 42" x 120"
1—Stokes Model 59DS steel rotary vacuum dryer, 5′ x 30′
1—Stokes double drum dryer, 5′ x 12′
1—Louisville rotary steam tube dryer, 8′ x 45′
1—Louisville SS rotary kiln, 30" x 28′, complete
1—Louisville rotary dryer, 38" x 40′, Type L
1—Louisville rotary steam tube dryer, 38" x 20′
3—Louisville SS Rotary Dryers, 8′ x 50′
1—Link Belt steel roto louver dryer, model 1003-30

FILTERS

3—Dorco 6′ x 2′ rubber covered filters
1—Sweetland #3 SS filter
1—Niagara SS filter, Model 510-28
1—Oliver horizontal filter, 3′
1—Feinc SS rotary vacuum string filter, 3′ x 3′ (NEW)
10—Shriver plate and frame filter presses, 12" to 42"
12—Sweetland #12 filters with 72 SS leaves
1—Shriver rubber lined filter press, 36" x 36"

MIXERS

1—Patterson jacketed vacuum SS sigma blade mixer, 300 gal.
3—Robinson type 316 SS sigma type jacketed heavy duty mixers, 400 gal.

THE GELB GIRL—JUNE 1959

5—Baker Perkins double arm sigma blade mixers, 100 gal.
1—Patterson monel double cone blender, 4 cu. ft.
19—Robinson SS horizontal bleaders, 255 cu. ft.
1—12′ x 4′, type 316 SS, Pug Mixer
1—Munson Rotary Blender, 40 cu. ft.

MISCELLANEOUS

2—Heat Transfer Products steel bubble cap columns, 36" and 42" with 5 and 10 trays
1—Acme steel bubble cap column, 42" dia. with 10 trays
2—Patterson-Kelley steel heat exchangers, 1000 sq. ft. each
6—Struthers Wells heat exchangers, 885 sq. ft.
1—Patterson-Kelley steel heat exchanger, 427 sq. ft.
50—Steel heat exchangers from 15 sq. ft. to 400 sq. ft.
1—Struthers Wells type 316 SS heat exchanger, 330 sq. ft.
10—Davis Engineering type 316 SS heat exchangers, 85 sq. ft. to 170 sq. ft. (NEW)
1—Badger type 316 SS bubble cap column, 42" dia. with 11 trays
1—Badger type 316 SS bubble cap column, 36" dia. with 8 trays
1—Vulcan SS bubble cap column, 4′ x 28 plates
3—Robins shaker screens, S. S. 3′ x 6′
1—Stokes Model DDS2 rotary tablet press
1—Struthers Wells SS calandria type evaporator, 365 sq. ft.
1—Swenson type 316 SS vacuum crystallizer, 3′6" x 12′
1—Swenson type 316 SS vacuum crystallizer, 2′ x 12′
1—Swenson single effect evaporator, SS., 320 sq. ft.
1—Blaw-Knox steel distillation column, 36" x 40′ with 24 trays, complete (NEW)
3—Williams type 316 SS hammermills, Model AK
1—Mikro Model 4th pulverizer
7—Milton Roy proportionating pumps, S.S. 1½ GPH to 156 GPH

1—Ames 300 HP steam generator, 150#
1—Badger monel bubble cap column, 4′ dia. with 17 trays
8—Aico type 316 jacketed reactors, 3000 gal. complete with agitators and drives.
2—Struthers Wells type 316 SS jacketed reactors, 3500 gal. complete with coils, agitators and drives.

Established 1886

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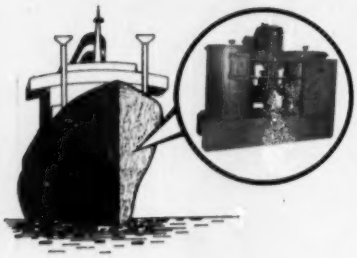

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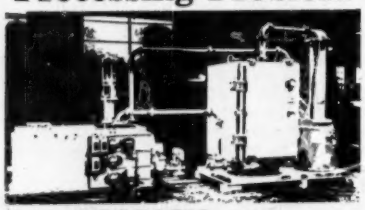

BIG PROBLEM

To remove a foreign element from a product without changing the nature of the product and recovering the foreign element.

SOLUTION, A Devine design vacuum chamber dryer using a dual heating shelf. Steam was the pre-heating element, molten salt furnished the elevated temperature.

J. P. Devine can solve your problems, regardless of how tough they are. For complete information, write:

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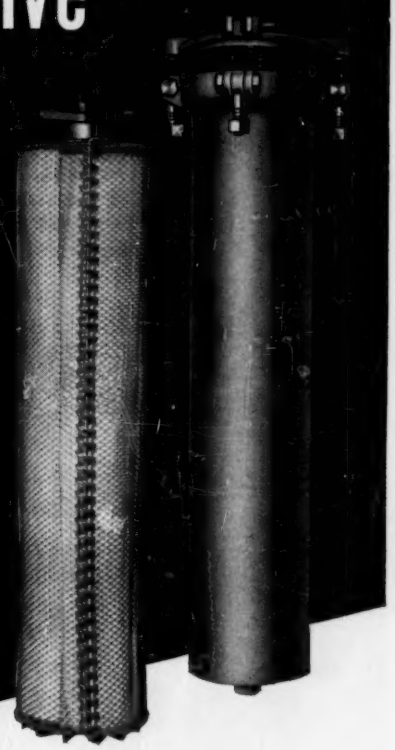
For Effective Filtration of MEA DEA DEG Solutions



You can rely on this NUGENT FILTER

When the job calls for filtering amine or glycol solutions, the Nugent Bag-Type Filter is the economical answer. All metal cartridge components are fabricated of stainless steel for MEA and DEA solutions, offering maximum resistance to the corrosive action of the fluid. The bags themselves are of close, evenly woven, lintless, acid-resisting textile material.

These filters will remove foreign solids as small as .0017". Gas processing plants employing amine solutions for scrubbing have found Nugent filters the ideal method for removing iron sulfide formed by this operation. Heat exchangers and other equipment within the plant receive maximum protection from clogging when Nugent filters are introduced into the processing system.

If your equipment demands this kind of protection, give it the benefit of Nugent filters. Available in a wide range of sizes and types. Write for complete information.

ESTABLISHED 1897

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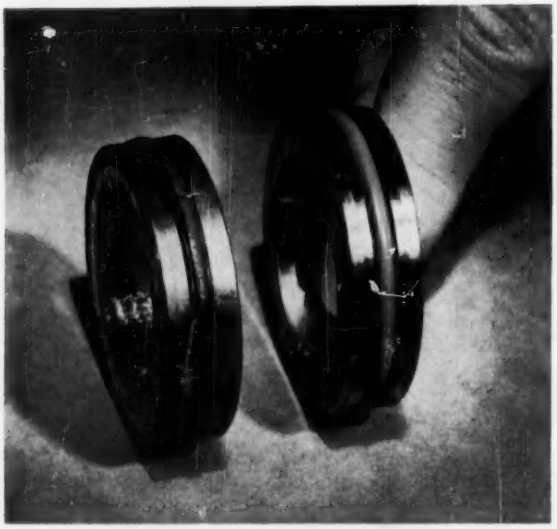
VITON® O-Rings seal heat exchanger at 525° F. —outlast other synthetic rubbers 25 to 1



Kontro Adjust-O-Film centrifugal processing units are commonly used as continuous evaporators. They operate by spinning the product in a thin film against a heat transfer surface. Heat exchange is extremely fast and hold-up very low, so high temperatures can be used.

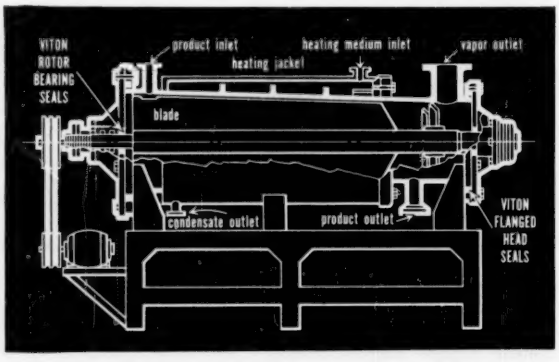
Bearing seals from pilot plant model (shown above) operated at 525° F. The one on the left was made from a standard synthetic rubber; the one on the right from VITON. Performance like this led to use of VITON on commercial models of the heat exchanger. Location of VITON seals is indicated in the diagram, right.

Expose most synthetic rubber O-ring seals to temperatures as high as 525° F. . . . subject them, at these high temperatures, to chemicals like fatty acids, dibasic acids, phthalic acid, solvents and petroleum products. Do all this, and *you know* what happens: the rubber loses its strength and resilience; it becomes useless as a sealing material. The only thing you can do is cut back your operating temperature to protect the seals.

That's exactly what The Kontro Company, Inc., had to do on one processing job for their new centrifugal heat exchanger. They had to restrict product temperature to 400° F.—125° below the 525° F. needed for optimum performance.

But that was before VITON. VITON synthetic rubber changed everything. Kontro's own tests show that VITON O-rings work just fine in intermittent operation of these heat exchangers at 525° F., lasting 12 to 25 times longer than other synthetic rubbers that have been tried.

Learn more about VITON. In O-rings, gaskets, hose, tubing and other resilient parts, you often need VITON'S ability to withstand operating temperatures of 400° F. to 450° F. continuously . . . up to 600° F. intermittently. You often need its unmatched resistance to oils, fuels, solvents, and corrosive chemicals. VITON has good mechanical properties, too—low compression set, high modulus, and good tensile strength . . . plus resistance to oxygen, ozone and weathering. Write for complete technical information to E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. CE-6, Wilmington 98, Delaware.



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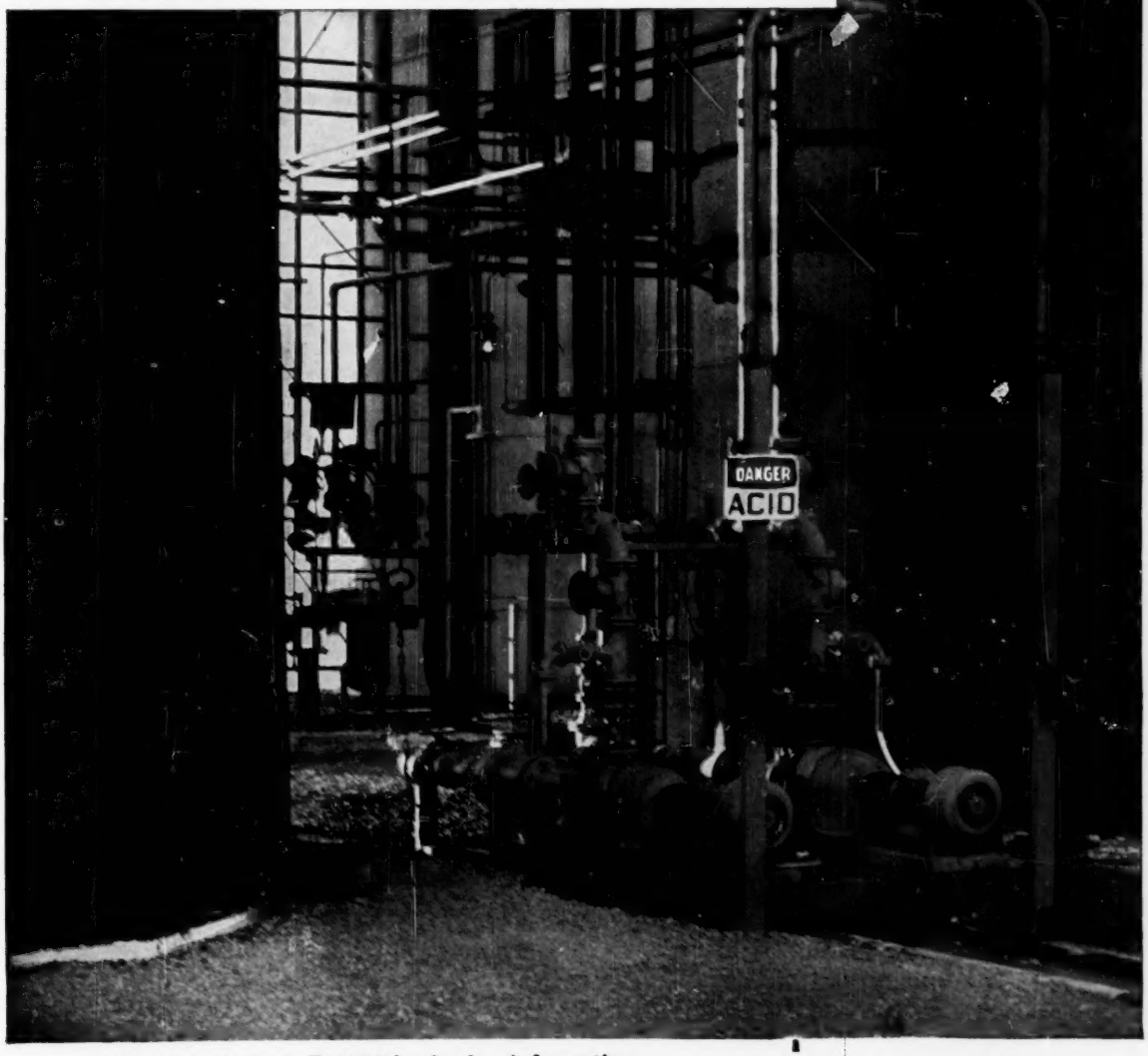

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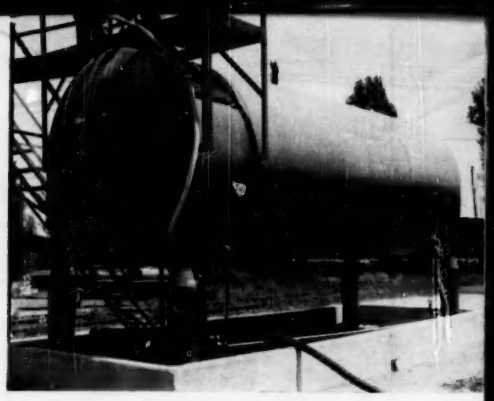
B-1873

FLUIDICS

is a Pfaudler Permutit program providing the know how, the equipment, and the experience for solving problems involving fluids. An example of how FLUIDICS can economically solve your fluid storage problems is described below:



Glasteel storage above 10,000 gallons costs less than stainless steel

Whenever you store 10,000 gallons or more of any chemical you'll want Glasteel Chemstor tanks simply *on a price basis.*

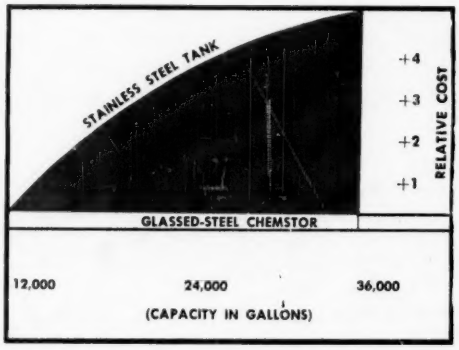
The difference in price is so striking that when you get in the 30,000 gallon range, Chemstor tanks actually cost about half as much as comparable stainless steel tanks.

Above or below 10,000 gallons you get all these advantages with Chemstor tanks:

Chemically inert glass is all that ever touches your product. You never need worry about corrosion, contamination, or other undesirable influences on your product.

Smoother surfaces than even the most highly finished metal or plastic. Chemstor tanks are ideal for products that tend to cling. The smooth as glass surfaces discourage clinging, scale, and product build-up.

High strength is still another feature of glass bonded to steel the Pfaudler way. You get years of service with sensible handling and maintenance.



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